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THE METAL SCHEDULE OF THE NEW TARIFF law, which was signed by President McKinley and went into effect on July 24, more nearly approaches the Wilson-Gorman law than it does the McKinley law. In many cases the rates of the Dingley tariff are exactly the same as those of its predecessor, which latter were much below those of the McKinley tariff. In other cases the figures of the new law are even below those of the Wilson-Gorman law. Notable exceptions are: Tin plates, 1.5 cts. per lb., as compared with 1.2 cts. in the Wilson-Gorman law, and band iron, used for cotton ties, etc., 0.5 cts., which was free under the Gorman law. The following is a condensed comparison of the duties levied under the three acts:

	McKinley. 1890.	Wilson. 1894.	Dingley. 1897.
Pig iron, per ton	$6.72	$4.00	$4.00
Charcoal bars, blooms, etc., per ton	22.00	12.00	12.00
	cts.	cts.	cts.
Iron ore, per ton	75.0	40.0	40.0
Bar iron, per lb.	0.8, 0.9 and 1	0.6	0.6
Round iron in coils, per lb.	1.1	0.8	0.8
Beams, channels, etc., per lb.	0.9	0.6	0.5
Plate iron and steel, per lb.	0.5	0.5	0.5
Plate iron and steel, value above 1c. per lb., per lb.	0.8	0.6	0.6
Anchors, per lb.	2.3	1.5	1.5
Forgings, per lb.	2.3	1.5	30%
Hoop, band or scroll iron, per lb.	1	30%	0.5
Railway bars, per lb.	0.6	0.35	0.35
Sheet iron and steel, per lb.	1.0	0.7	0.7
Sheet iron and steel, galvanized, additional, per lb.	0.75	0.25	0.20
Sheet iron and steel, polished, per lb.	2.2	1.75	2
Tin plates, per lb.	2.2	1.2	1.5
Steel ingots, blooms, etc., per lb.	0.4	0.3	0.3
Wire rods, per lb.	0.6	0.4	0.4
Wire, not smaller than No. 13, per lb.	1¼	1¼	1¼
Anvils, per lb.	2½	1⅞	1⅞
Axles, per lb.	2	1½	1¼
Cast-iron pipe, per lb.	0.9	0.6	0.4
Malleable casting, per lb.	1.75	0.9	0.9
Chains, not less than ¾ in., per lb.	1.6	30%	1⅛
Boiler tubes, per lb.	2½	25%	2
Cut nails, per lb.	1	22½%	0.6
Wire nails, per lb.	2	25%	0.5
Wheels for railway purposes, per lb.	2½	1¼	1½
Aluminum, cast, per lb.	15	10	8
Aluminum, rolled, per lb.	15	10	13
Antimony, per lb.	3%	free	¾
Copper, in bars, ingots or pigs, per lb.	..	..	free
Copper in rolled plates (brazier's copper), per lb.	35%	20%	2½
Lead ore, per lb. of lead therein	1½	¾	1½
Lead, in pigs, etc., per lb.	2	1	2½
Nickel, per lb	10	6	6
Quicksilver, per lb.	10	7	7
Tin, in bars, pigs, etc., per lb.	..	..	free
Zinc, in blocks or pigs, per lb.	1¾	1	1½

The principal changes of interest to the electrical trade are increases on carbons, mica, zinc, copper, german silver, lead, rubber, acids and battery chemicals, asphaltum and other insulating materials, telegraph and other poles and railway ties.

A RAILWAY FROM CHIHUAHUA TO THE PACIFIC has been authorized by the Mexican government, and a concession has been granted to A. A. Spendlee and E. C. Creels; the first named is the general manager of the Chihuahua Mining Company, of Chihuahua, and Mr. Creel is a banker of the same place. Under the terms of the concession the total length of the line is 378.2 miles, from Chihuahua to a point on the Pacific Coast in the State of Sonora. Plans for the first section of 124.3 miles must be sent in before April 13, 1898, and on completion of each of the three sections of like length subsidies of $1,400,000, $1,800,000 and $1,400,000 will be paid in 5% bonds of the Interior Redeemable Debt. Another concession, without subsidy or government aid, has since been granted to Col. A. K. Owen for a railway from Presidio del Norte, on the Rio Grande, State of Chihuahua, west, via the city of Chihuahua, to a point on the Pacific Coast in the State of Sinaloa. These roads are intended to develop the vast mineral wealth of Chihuahua by cheapening transportation and fuel.

MATERIAL FOR MACADAMIZED ROADS, TRACK ballast, station platforms, roundhouse floors and other similar purposes is being obtained on the main line of the Union Pacific, about two miles east of the Ames monument on Sherman summit, between Cheyenne and Laramie, Wyo. The material is described as disintegrated red granite, occurring in cubes ¼ to ⅝-in. in size, very clean, compacting and cementing when wet to form a smooth, hard surface. Mr. E. Dickinson, of Omaha, General Manager of the Union Pacific, informs us that his company is now loading 125 to 175 cars per day with this material for use in ballasting its main track in eastern Nebraska. He states that the material is excavated and loaded with steam shovels and that the quantity is unlimited. Mr. H. B. Patten, M. Am. Soc. C. E., City Engineer of Cheyenne, Wyo., informs us that the material has been used for many years for walks and driveways through public parks, and that recently the Union Pacific Ry. Co. has been using it in place of plank for station platforms. Mr. Patten describes the material as disintegrated feldspar. From another reliable source we learn that the material wears well as macadam and seems to make less dust than other stone used for that purpose; also that a similar deposit occurs near Larkspur, Colo., about 45 miles from Denver, on the Denver & Rio Grande Ry.

THE FAILURE OF THE MELZINGAH DAMS of the Fishkill & Matteawan Water Co., on July 14, as fully described in our issue of July 22, is attributed by the Coroner's Jury to deficient spillways. The Jury was of the opinion that the company is in a large measure responsible for the seven deaths caused by the failure of the dams, and censured the company for not providing a competent watchman, especially in the time of high water, to notify the people below of the impending danger. It is stated that damage suits have been brought against the company by the proprietor of the brickyard damaged by the flood, and also by the heirs-at-law of some of the victims.

THE MOST SERIOUS RAILWAY ACCIDENT of the week occurred July 23, on the Pittsburg & Western Ry., at Fombell, Pa. Heavy rains had washed out a culvert which sank as the engine was passing over. The engineer and fireman were badly scalded and were washed some distance down stream. No other fatalities are reported.

A FREIGHT WAREHOUSE TERMINAL at Chicago, for the accommodation of the wholesale merchants, is projected by the Merchants' Terminal Railway Co., on somewhat the same basis as the Cupples station at St. Louis, which has been described and illustrated in our columns. It is proposed to erect a group of warehouses having railway tracks on the ground floor, with connecting lines to the various railway systems, thus enabling merchants to receive their goods direct from the railway cars and ship them again in the same way, without any haul by wagon from the freight station to the individual warehouses. The terminal company will deliver cars and haul them from the basement, and will also arrange to handle the goods to and from the cars and the floors occupied by the various merchants, or it will allow such merchants as prefer to handle their own goods by their own trucks and elevators. The equipment will include an extensive elevator and lighting plant. The site proposed is along the river front, south of Harrison St., which is within half a mile of the Board of Trade and is convenient to the freight stations of a number of railways.

A CAR-FAMINE is feared by the Western railway companies, says the Chicago press. Instead of the demand for cars for shipping grain coming about Aug. 1, it has opened this year on July 1, and the shipments now are as heavy as in ordinary years on Aug. 10. These heavy shipments come from Kansas and the Southwestern wheat belt. It is not expected that the demand for cars from Iowa, Nebraska, Minnesota and Wisconsin will set in before the middle of August or first of September.

ASPHALT-FILLED MANHOLE COVERS for electric subways, etc., are being used in connection with the asphalt paving of Jackson St., Chicago, which street has been selected as a boulevard, and will be paved with asphalt from the river to the lake front, as a continuation of Jackson Boulevard. The iron covers have the sides, letters, etc., brought up to the street surface, and these are connected by stiffening ribs forming pockets into which the powdered Bermudez asphalt is filled and rammed.

BIDS FOR A NEW WATER SUPPLY FOR SAN FRANcisco are to be received on Sept. 20. Bidders are requested to describe the works they propose to build; to state the estimated cost of a daily supply of from 30,000,000 to 60,000,000 gallons, and of a distributing system of from 30 to 8-in. mains. Mr. John A. Russell is city clerk. The call for bids states that after bids are received an election will be held to vote on issuing the bond necessary for their construction.

MUNICIPAL IMPROVEMENT ASSOCIATIONS are being organized in certain districts of Chicago to provide for local improvements. The Wabash Ave. Improvement Association is one of these, and is making arrangements for cleaning the streets, painting and improving the buildings and shop fronts (which work can be done very cheaply under large contracts), and for providing arc lamps on the subscription system. A number of large firms on this avenue are members of the association.

A SEWERAGE COMMISSION FOR THE MENOMINEE River valley, above Milwaukee has just been appointed by the governor of that state. The members of the commission are F. W. Springer and Chas. Stickney, of Wauwatosa, and Charles Lapham, an engineer, of Milwaukee. It is stated that the commission is to report on a system to connect with that of the city of Milwaukee, and has an appropriation of $5,000 at its command. The city of Wauwatosa and a number of public institutions are located in this valley. The city of Milwaukee has spent large sums of money to clean up the valley within its limits, and the proposed work is in continuance of this. A number of small sewage purification plants for manufactories have been built in the valley, as described in our issue of June 13, 1895, but it is claimed that these were either not adequate, or were improperly operated, while sewage from other sources reached the river untreated.

THE DRAINAGE OF THE HOBOKEN MEADOWS is being discussed by the Mayor and Councils of that city. This would be done by the establishment of a pumping plant and the completion of a satisfactory levee system. The property-owners would be assessed for the cost and the Mayor estimated that a charge of $2.50 to $3.00 per year per building lot would maintain the pumps. The Health Board is enlisted in the project and the legislature of New Jersey will be asked to authorize a special appropriation for the purpose of drainage.

A CONTRACT FOR A PORTION OF THE NEW ORleans drainage system has been awarded to the National Contracting Co., of New York, represented at New Orleans by Mr. M. F. Mullen, Hennepin Building. The work includes lined and covered and unlined and uncovered canals, three pumping stations and a central electric power station. The aggregate contract price is $1,257,053. Mr. B. M. Harrod, Prest. Am. Soc. C. E., is Chief Engineer of the Drainage Commission of New Orleans, and Mr. L. W. Brown will be chief engineer for the contractors. Mr. Brown was city engineer during the preliminary work of preparing the drainage plans. The detailed bids for the work covered by the present contract may be found under Contract Prices in our issues of July 22 and of this date.

A COMBINED TRIANGLE AND PROTRACTOR has been upon put upon the market by Schwencke, Kirk & Co., of 26 Church St., New York. It is a celluloid triangle, perfectly transparent; and with the long side as a base is a protractor with the graduations and figures plainly stamped into the transparent celluloid. To draw a line at any required angle to a given line, it is only necessary to place the triangle so that the centre of the graduated arc and the number of the required angle are directly over the given line; a line ruled along the chord of the arc then gives the angle. As the graduations are on the under side of the triangle extreme accuracy is possible. These multi-angles of 45° are kept in stock, ranging in size from 5 to 14 ins., and they cost from 90 cts. to $3.60.

THE GOVERNMENT ARMOR PLANT, recommended by the last Congress, will be considered by a board which is about to be appointed by the Secretary of the Navy, and this board will prepare plans and specifications for the construction of such a plant. It is reported that the Bethlehem Iron Company may offer to lease its plant to the government, and the Carnegie Company may make a similar proposition.

THE NEW EAST RIVER BRIDGE COMPANY, having obtained 2½ acres of land from the American Sugar Refining Company, for $350,000, may now complete its approaches on that side. At the present time one caisson is down, at the foot of Delancey St., New York, and another is under construction at the foot of North First St., Brooklyn. Two caisson foundations are required for each main tower. The bridge will not be completed until 1900, and the total estimated cost is $7,500,000. The contract for the foundations of the New York tower were let to T. H. Flynn, in October, 1896; and the Brooklyn tower foundations have just been awarded to Calin McLean, of New York.

NEW FERRY HOUSE AT SAN FRANCISCO, CAL.

The Harbor Commissioners of San Francisco, Cal., are having a large ferry house built at the foot of Market St. to accommodate the heavy suburban traffic to points on San Francisco Bay and the main line traffic of the railways, all of whose passengers have to be ferried across the bay. At present there is a very awkward arrangement, and the continuous procession of cable cars interferes considerably with the streams of passengers to and from the ferry house. A general view of the new structure, reproduced from the architect's perspective sketch, with the approach bridge and the rearranged terminals of the cable lines, is shown in Fig. 1. Mr. Page Brown, of San Francisco, was architect for the building, and the work was designed by and is being carried out under the supervision of Mr. Howard C. Holmes, Chief Engineer of the Harbor Commissioners, to whom we are indebted for drawings and specifications. The following is an extract from Mr. Holmes' last annual report, dated Sept. 12, 1896:

The foundation of the approaches to ferry slips Nos. 2, 3, 4, 5 and 6, which will also serve as foundation for the new union depot and ferry house, was completed Sept. 1, 1895. The same consists of 111 concrete piers of the dimensions of 16 × 28 ft. at the base and of 8½ × 28 ft. at the top, with a depth of 20 ft. below city base, and also portion of the concrete seawall in front of Section 8a and 8b. These are joined together by a series of groined concrete arches (2 ft. thick at the soffit) into one immense area of floor space, 100 ft. in width by 670 ft. in length. This enormous foundation rests on a sub-foundation of grillage supported by over 5,000 piles, each not less than 80 ft. in length; 28,000 cu. yds. of concrete with 36,000 bbls. of cement were required in the construction of the arches and floors. Assuming the weight of concrete to be 4,000 lbs. per cu. yd., the total weight of this structure would be 112,000,000 lbs., or 56,000 net tons.

This piece of concrete, pile and grillage work is undoubtedly one of the largest, if not the largest, of its kind in the world, and required the removal of some 3,000 old and submerged piles, in addition to the concrete, pile and cement work above mentioned. In the course of its construction some 30,000,000 people passed to and fro over the scene; on an average 150 men were employed continuously for over two years; there was not an accident of any kind whatsoever; and ferry-boats made half-hourly trips from the locality and were not delayed one minute and did not lose a single trip during the whole time. This, I think, is a very creditable showing.

As questions were raised regarding the strength of this foundation and its honesty of construction, Professor Soule, head of the Department of Civil Engineering of the University of California, and Professor Marx, head of the Department of Civil Engineering of the Leland Stanford, Jr., University, were called upon to make a thorough examination and report to the Board. The concrete samples and blocks taken by these gentlemen from four different portions of the foundation, indiscriminately, were, in the case of the poorest, 40%, and in the case of the best, 90%, above the average strength of concrete of that age. These samples sustained a pressure from 90 to 100 tons per sq. ft. As further proof of the strength of the construction there have been laid 15-ton girders in such position over the arches as to concentrate a load on them which is about 120 times greater than any that they could possibly be compelled to sustain in the use for which they were designed.

The original contract price for this work was $247,887, but changes during the course of construction were suggested by me which reduced the above amount $8,109, without impairing the strength or utility of the structure. These changes involved a saving also in the amount of cement used, so that in place of 40,000 barrels, as contemplated by the original specifications, only 36,000 barrels were used, thus reducing the cost of the foundations about $17,000.

From the foundation plan, Fig. 2, it will be seen that the foundations consist of rows of pile clusters, with from 50 to 60 piles to each group, the groups being 28 ft. 6 ins. apart longitudinally. The total length between the center lines of the end clusters is 659 ft., and the width from the center of the sea wall or bulkhead wall to the center line of the center row of pile clusters is 157 ft. 5 ins. The first two rows of clusters have 60 piles to each cluster; the next row has 54 piles to each cluster, and the outer row has 16 piles to each cluster, except that a few old piers are utilized, having only 9 piles each. The piles are driven about 3½ to 4 ft. apart, those under the tower being 4 ft. apart, and the dimensions of the piers given in Fig. 2 represent the size of the bottom course of concrete in each case. Some details of the piers and piling are shown by Fig. 3.

FIG. 1.—VIEW OF NEW FERRY HOUSE AT SAN FRANCISCO, CAL.
Page Brown, Architect. Howard C. Holmes, Chief Engineer.

A general view of a portion of the structure, with a section showing the pile foundations and the monolithic concrete piers and floor arches (as referred to in Mr. Holmes' report, quoted above), is given in Fig. 4. It will be noted that the floor is tied together solidly by horizontal rods embedded in the concrete, these rods extending across the arches and having anchor plates in the concrete of the haunches.

The ground plan, Fig. 5, shows the arrangement of the railway waiting rooms, baggage rooms, ticket offices, etc.; also the ferry boat slips, the aprons and the approaches. Local passengers, or those already provided with tickets, can go directly to the boats, and all passengers arriving can go directly to the street without passing through the waiting rooms. The wide platform between the offices and the slips allows of the distribution and dispersal of the crowd. On the upper floor, Fig. 6, are more waiting rooms, ticket offices, a restaurant and the offices of the Harbor Commissioners. From the passageway outside the waiting rooms, bridges extend to connect with the upper decks of the ferry boats, as shown. The exit gates on both floors are to be steel corrugated rolling gates, rolling noiselessly on overhead drums.

The piles are of fresh-cut Oregon pine, 80 ft. long, 16 ins. diameter at the butt, and not less than 7 ins. at the top. They are driven till their heads are 20 ft. 6 ins. below base line and are cut off 21 ft. 6 ins. below base line. Oregon pine caps are used, 14 × 18 ins., each cap secured to each pile by a drift bolt 1 × 24 ins. The caps under the towers are 12 × 12 ins., with 1¼-in. screw bolts 3 ft. apart. The planking for the bottoms of piers, on the caps, is in alternate pieces of 6 × 12 and 4 × 12-in. Oregon pine planks, each piece spiked to each cap with wrought spikes, ½ × 10 ins. and 5 × 9 ins., respectively, all bored spiking.

The concrete for the piers is composed of 1 barrel of cement, 6 cu. ft. of clean sharp sand and 24 cu. ft. of broken washed trap rock of not more than 1¾ ins. in greatest dimension. The broken stone was first spread on a wooden platform in a layer not exceeding 6 ins. in thickness; on this was spread (over its entire area) first a layer of sand and then a layer of cement, each in its proper proportion. The bed thus formed was turned with shovels, twice while dry and once after being wet.

The space for each concrete pier was thoroughly coffer-dammed and pumped out and excavated to the bottom of the caps. The concrete, previously prepared, was then spread in layers not exceeding 4 ins. in thickness, uniformly and properly smoothed, and well tamped with iron-shod tamping bars of at least 12 lbs. weight, until the water rose to the surface. During the process of setting, after 24 hours, all concrete was kept constantly wet with clean, fresh water for at least seven days, and covered from the sun and kept free from all contact with salt water.

From the springing line of the arches, 3 ft. 6 ins. below the city base, to a point 1 ft. above the city base, the piers and concrete arches and vaults are constructed of Portland cement concrete in the proportion of 1 barrel of cement to 18 cu. ft. of rock and 4 cu. ft. of sand. The broken stone for this work was not larger than 1 in. at its greatest dimension. Special precaution was used in this part of the work to employ only the very best quality and cleanest broken stone and the sharpest sand, and care taken thoroughly to grout and pack the bearings of the anchors. The vaulting was constructed in alternate bays, every other bay or vault being built and allowed to set 30 days before the alternate bays were built.

The soffits of all the arches, vaults, etc., are plastered with cement mortar made in the proportion of 1 part cement to 1 part of sand. This plastering was applied in one coat ¼ in. thick, troweled smooth, and allowed to dry thoroughly before being exposed to the salt water. The cement plastering was wet every day with fresh water and kept covered from the sun and protected from the

salt water in the same manner as the concrete piers and arches.

The iron tie rods, which have already been referred to as being built into the concrete, are 2 ins. diameter, with upset ends, and a cast iron anchor on each end. The bottoms of these rods are at least 6 ins. above the crown of the soffit of the arch or vault. In the concrete pier forming the tower foundation there are 16 vertical 3-in. rods, with upset ends, the top being fitted with a nut and washer and the bottom fitted with a cast iron ribbed anchor, $3\frac{1}{2} \times 3\frac{1}{2}$ ft.

The structural frame work is of steel, both open hearth and Bessemer steel being permitted by the specifications. The test specimens were required to show an ultimate tensile strength of 60,000 to 68,000 lbs. per sq. in., an elastic limit of half the ultimate strength, a minimum elongation of 20% in 8 ins., and a minimum reduction of area of 40% at the point of fracture. This grade of steel was required to bend cold 180° to a diameter equal to the thickness of the piece tested, without a crack or flaw on the outside of the bent portion. The steel for the rods was of the same quality, but the elongation and reduction of area were 5% and 10% less than as above specified.

The exterior of the building is to have foundation walls of granite. The entire exposed surfaces of the exterior of the building, as well as the exterior of the tower, and the masonry of the inside surface of first story front walls, the piers, arches, etc., forming the colonnade at the sides of the same, above spring line of arches, are to be faced with speckled buff colored Roman "mud pressed brick," or, if dry pressed brick, of quality approved by the architect. These bricks are to be $12 \times 1\frac{3}{4} \times 4$ ins., of a shade selected by the architect. They are to be laid in cement mortar, with headers every fifth course, to be formed by clipping the face brick and putting in a diagonal header—all of Roman brick. All the stair wells are to be faced on both sides with white enameled brick. The face brick and terra cotta trimmings up to a height of spring of arches in grand nave and waiting room side of piers, and to a corresponding height on ends and front entrance, also whole of staircase walls, are to be treated on all exposed faces with white enamel finish. Above the line of spring of arches in grand nave, also on waiting room side, the walls will be faced with Roman brick and buff terra cotta, as before specified, or with white enameled brick.

The partitions are to be of 4-in. hollow tile fireproofing, and the same material is to be used to protect the iron girders and columns.

The roofs, including roofs of passenger bridges (except such portions as are covered with skylights) are to be covered with No. 20 corrugated galvanized iron. All corrugated iron to be 2.425 ins. c. to c. of crown of corrugation. All side joints are to overlap two corrugations and to be riveted together. All lap joints to overlap not less than 7 ins., also to be riveted together; the rivets are in no case to be more than 3 ins. apart, and each section of roofing is to be thoroughly secured to the purlins by means of wrought iron clips fastened to the under side, riveted on the roofing and the clips in turn riveted to the purlins. All rivet heads and clip connections to be soldered on top and made perfectly water tight. The skylights are to be glazed with wire glass ¼ in. thick, 1¼-in. mesh.

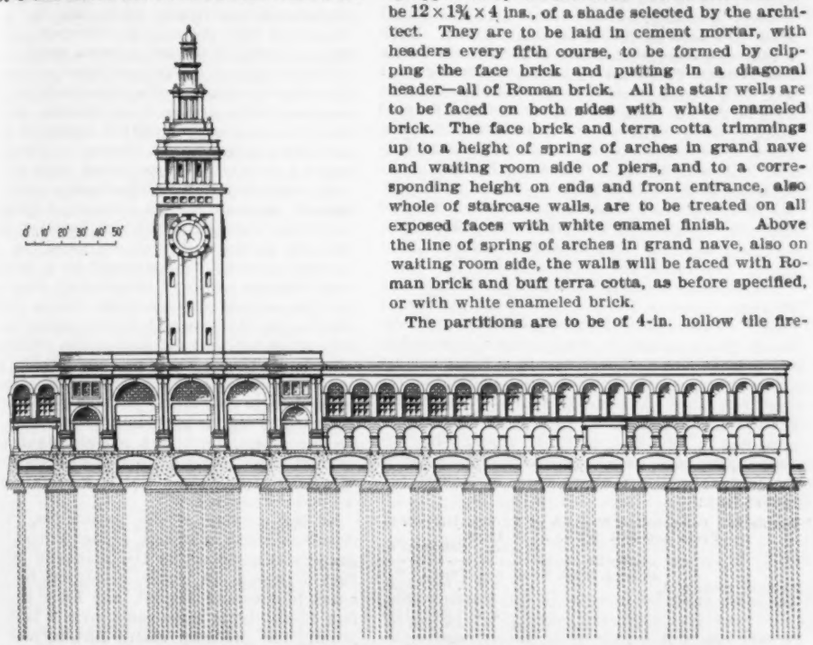

FIG. 4.—PART ELEVATION OF FERRY HOUSE AND VERTICAL SECTION OF FOUNDATIONS.

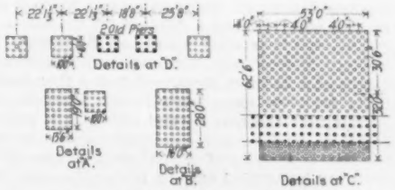

Fig. 3. Details of Piers and Piling.

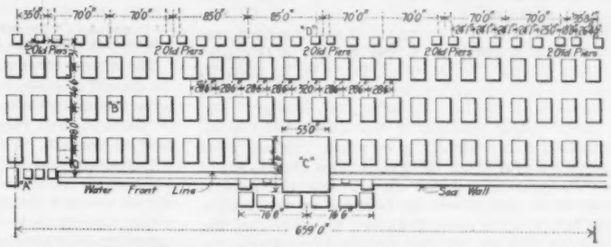

FIG. 2.—FOUNDATION PLAN, SHOWING ARRANGEMENTS OF PILE CLUSTERS.

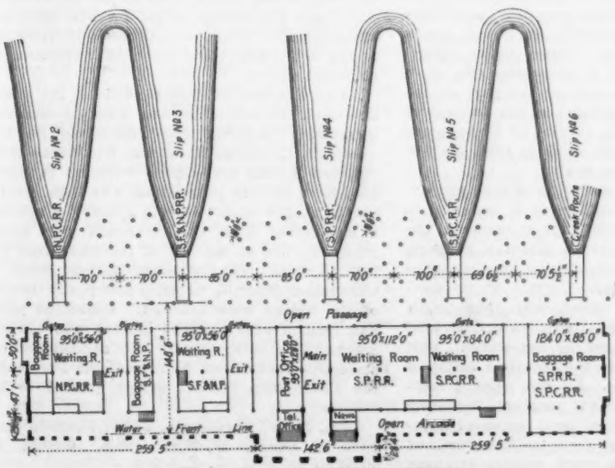

FIG. 5.—PLAN OF GROUND FLOOR.

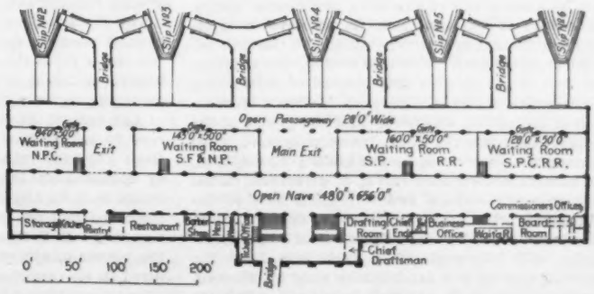

FIG. 6.—PLAN OF SECOND FLOOR.

THE ANNUAL MEETING OF THE ASSOCIATION OF GERMAN PORTLAND-CEMENT MANUFACTURERS.

Abstracted by S. B. Newberry.*

The 20th annual meeting of the Association of German Portland Cement Manufacturers took place in Berlin, Feb. 24 and 25, 1897. The full report of the proceedings has just appeared.† The association now includes representatives of 81 factories, the total production of which amounted in 1896 to more than 15,000,000 barrels of cement.

At the opening of the meeting a discussion took place in regard to the duty imposed upon German cement by Austria and Russia. The Austrian import duty is 45½ cts. per barrel; the Russian, 70 cts. per barrel. It is stated that these duties bear heavily upon the German manufacturers, and have greatly reduced the exportation of cement to these countries. On the other hand, Austrian and Russian cement is admitted to Germany free of duty. The Minister of Commerce was requested to endeavor to secure a reduction of these duties, or, if this should be impossible, to impose a duty on foreign cement imported into Germany. The statement was made that the German cement industry has nothing to fear from fair foreign competition, and that if the Austrian and Russian duties could be reduced one-half no need for a German import duty would exist. In the discussion no mention was made of the duty of 32 cts. per barrel imposed by the United States. From this circumstance, and from the fact that 1,366,909 barrels of German Portland cement were exported to the United States in 1896, it appears that this duty does not constitute a serious hardship to the German manufacturers.

* General Manager Sandusky Portland Cement Co., Sandusky, O.

† Protocoll d. Verh. des Ver. Deutscher Port-Cement Fabrikanten. Berlin: R. F. Funke, 1897.

Plans were proposed for the participation of the association in the conference of the International Association for the Testing of Materials of Construction, which takes place this summer in Stockholm. It was suggested that a large steamer be chartered to carry German and foreign representatives from Stettin to Stockholm, thus offering an attractive sea voyage and an opportunity for delegates from various countries to become known to each other.

Referring to the proposed representation of the association at the Paris Exposition of 1900, it was recommended that this take the form of a collective exhibit, in which the materials and products of each factory should be separately displayed, with large photographs of the works. A well-arranged plan for the whole exhibit, with the use of uniform glassware and pedestals, would result in an effective and harmonious display.

Report of the Committee on Normal Sand.—A tract of land at Freienwalde, 66 by 132 ft. in area, forming part of the famous sand deposit, has been leased in the name of the association, for the purpose of insuring a constant supply of sand of uniform quality for cement testing. This tract was estimated to be sufficient to supply all the sand required for official tests during a period of at least 50 years. It was resolved that the supervision of the digging of this sand and the preparation of it for use should be left with the Royal Testing Station at Charlottenburg. Normal sand is that which passes a sieve of 20 meshes to the lin. in., and is retained on one of 28 meshes. The committee separated this into two fractions by means of a 24-mesh sieve, and found that each of these fractions gave lower results with a given cement than the true normal sand. It is evident, therefore, that considerable differences may exist in different samples of normal sand. These differences can be avoided only by taking the sand from a single locality.

The Royal Testing Station lately requested a number of manufacturers to state whether they were in the habit of using the Frienwalde normal sand in their regular tests. Many of them replied that they prepared their own normal sand from other sources. Comparative tests of these sands and the Freienwalde normal sand, reported by these manufacturers, showed differences amounting in some cases to 50%.

Herr Gary showed enlarged photographs of the normal sands employed in ten different countries, and stated that comparative tests of these sands are in progress at the testing station. Certain countries, especially Switzerland and America, use no natural normal sand, but employ artificially-broken quartz. In America there is, in fact, no normal sand, the American test being made with neat cement of the consistency of mortar. The crushed quartz consists of extremely sharp splinters, and will evidently give much higher tests than a natural sand. In France two normal sands are recognized, crushed quartz and the natural sand from the shores of Lencate in the Andes. The latter is the sand proposed for universal use by Prof. Debray, of the French Commission for the Unification of Methods of Testing.

One great obstacle to the preparation of uniform normal sand is the variation in commercial sieves. Herr Gary stated that there is no sieve in existence which exactly corresponds to the German official requirements. For this reason, the committee were of the opinion that instead of prescribing the measure of sieves to be used, it should be specified in the official standards that the grains of the normal sand should vary between certain fixed diameters. As a check on the quality of the sand, the committee prepared sieves of perforated metal with square openings, and were thus able to obtain sieves with uniform openings, corresponding exactly to official requirements. Further experiments will determine what variations from the specified size of the sand-grains may be allowed. Details of this work will soon appear in a bulletin of the Testing Station.

Report of the Committee on the Action of Seawater on Hydraulic Cements.—The experiments at the Island of Sylt were begun anew in 1896, and are being conducted according to the following program. Tests are to be made of—Portland cement, Roman cement and Pozzuolana (slag) cement, each with 1, 2 and 4 parts sand. Trass, with slaked lime and sand, in the proportions of 1 to 1 to 1, 1 to 1 to 3, 1 to 2 to 3. All mortars are to be mixed with fresh water and test pieces made with the hammer apparatus.

Tests will also be made of Portland, Roman and Pozzuolana (slag) cements with 1 part sand, in the form of soft mortar, poured into the molds without pounding. Trass with 1 part lime and 1 sand will also be tested in this manner. Each tensile and compression test is to be made on six test-pieces. These are to be kept in moist air 1 day, then 6 days in sea-water, renewed daily, then kept in the sea until the time of testing. Parallel tests in fresh water are to be made in all cases. Tests will be made at the following periods: Tensile, 7, 28 and 90 days, 1, 2, 3 and 5 years; compression, 28 days, 1, 2, 3 and 5 years. The report for 1897 contains a tabular statement of the preliminary work on all the materials to be tested, including analysis, time of setting, tests for constancy of volume, etc.

Experiments made in 1895 showed that, of two Portland cements tested, the one containing a higher percentage of alumina gave slightly lower results in sea water. In order to test this question, the present series of experiments is being carried out with three Portland cements, containing respectively 4.98, 7.55 and 8.56 per cent. of alumina. Results up to 90 days, on all mixtures tested, are presented in tabular form in the report. The accompanying table shows the results obtained with the various mixtures at 90 days, in pounds per square inch:

Tensile and Compression Strength of Various Mortars in Fresh and Salt Water at 90 Days.

	Mortar, Cement.	Sand.	Tension, water. Fresh.	Tension, water. Sea.	Compress'n, water. Fresh.	Compress'n, water. Sea.
Portland cement, A. (Alumina, 4.98%.)	1	1[1]	617	515	7,027	5,654
	1	2[1]	420	344	4,426	3,530
	1	4[1]	226	207	1,398	1,113
	1	1[2]	563	470	4,843	3,512
Portland cement, B. (Alumina, 7.55%.)	1	1[1]	549	437	6,063	4,419
	1	2[1]	345	258	3,683	2,739
	1	4[1]	280	164	1,139	739
	1	1[2]	372	352	4,829	3,170
Portland cement, C. (Alumina, 8.56%.)	1	1[1]	504	511	5,768	4,479
	1	2[1]	372	327	3,305	2,788
	1	4[1]	185	156	1,057	843
Roman cement	1	1[1]	319	290	2,077	1,509
	1	2[1]	188	165	917	580
	1	4[1]	84	68	298	57[5]
	1	1[2]	198	210	1,010	637
Pozzuolana cement	1	1[1]	304	302	1,699	1,555
	1	2[1]	233	215	879	784[4]
	1	4[1]	101	119	355	242[4]
	1	1[2]	312	318	976	928
	Trass. Lime.					
Trass	1 1	1[1]	262	261	1,775	1,303
	1 2	3[1]	203	146	1,209	429[3]
	1 1	3[1]	182	146	1,003	Crkd.
	1 1	1[2]	215	160	871	473

[1] Pounded. [2] Poured. [3] Much cracked on the edges. [4] Somewhat cracked on the edges. [5] Swelled on the edges.

The above table and appended notes show that the poorer mortars made from Roman and Pozzuolana (slag) cement and from trass failed within 90 days in their resistance to the mechanical action of the sea. Full tables, showing the results of tests made in 1894 and 1895, up to two years, are also given in the report. These earlier experiments are not considered to be wholly free from errors, owing to lack of skill on the part of the operator to whom the making of the test-pieces was intrusted. From the results of these tests, however, in connection with those of 1896, the following conclusions may be drawn.

The Portland cements containing a high proportion of alumina show no difference in behavior in sea-water from the cements lower in alumina. The higher or lower percentage of alumina appears, therefore, to be without influence on the resistance of the cement to sea-water. Certain of the mortars to which lime was added, both those made from Portland cement and trass, were destroyed or attacked on the surfaces by sea-water. This result is to be attributed to the chemical action of the sea-water on the lime. All rich cement mortars and all Portland cement mortars, including the poorer mixtures (1 to 4), have remained uninjured in sea-water up to two years. The Portland cement mortars acquired much greater strength than the others. In the case of all hydraulic materials, the strength attained in sea-water is less than that in fresh water.

A discussion then took place on the subject of certain views lately published by Dr. Wm. Michaelis. The arguments of Dr. Michaelis are that Portland cement in hardening separates crystalline calcium hydroxide, and that this reacts with the magnesium sulphate of sea-water to produce calcium sulphate and a compound calcium sulphate and aluminate. The formation of these crystalline products is the cause of the destructive action of sea-water on cements. This injurious action may, however, be prevented by adding to the cement a certain proportion of a natural puzzuolana such as trass, which has the power of combining with the calcium hydroxide set free in the hardening of cement, forming stable silicates.*

In consequence of the publication of these views by Mr. Michaelis, and of a claim made by the leading proprietors of the trass deposits near Bonn, that the experiments at the Island of Sylt had done them injustice, the Minister of Public Works called a conference of prominent experts to determine whether the above experiments could be considered adequate for the purpose of deciding the important question of the resistance of hydraulic mortars to the action of sea-water, or whether further experiments, conducted on a larger scale with concrete blocks of considerable size, were desirable. At this conference the plan of conducting further experiments was warmly approved, but it was estimated that the cost of the proposed tests of concrete blocks would be considerable, and further consideration of the subject was postponed until definite estimates could be prepared and a scheme devised for providing the necessary funds. In the meantime it was recommended that the present experiments be carried to a conclusion as originally planned, and that they be extended over a period of ten years.

At the meeting of the association, Professor Schuliatschenko of Russia, replied at length to the arguments advanced by Dr. Michaelis. He stated that in Russia all harbor constructions are executed in Portland cement, and have shown perfect durability, in some cases, over a period of 25 years. The professor stated further that he had inspected these constructions, and also those at Cherbourg, Marseilles, Toulon, Boulogne, and other foreign harbors, and in an experience of over 25 years he had not met with a single case of failure of Portland-cement concrete under the action of sea-water. These favorable results are doubtless partly due to the formation of a protective coating on the concrete surfaces from the materials suspended in sea-water. These consist of extremely fine sand and clay, mixed with minute animal and vegetable organisms. Penetrating into the pores of the concrete, they render it almost entirely impervious. Further, the living germs grow where they attach themselves, and with the aid of the carbonate of lime formed by the carbonic acid contained in the water, they produce a dense and almost impenetrable crust upon all the exposed surfaces. If cases of failure of cement-concrete should occur, these should be investigated fully, and the causes of failure will be found in circumstances which prevent the protecting action above described, while favoring corrosion from chemical causes.

As an example of such conditions, the professor described the following case, which presents some interesting features: The building of the breakwater in the harbor of Odessa was begun in 1872. Concrete blocks made from Portland cement and also from Roman puzzuolana and lime, were employed in this work. During a heavy winter storm a number of these blocks, which were standing ready for use at the end of the pier, were forced into the sea. The following spring, when these were taken from the water, it was found that many of the blocks were cracked; stalactitic growths had formed where cracks existed, and out of the cracks ran a milky liquid. The composition of the stalactitic formations, both from the Portland and the Pozzuolana cement blocks, proved to be as follows:

Lime, 31.60%; magnesia, 27.10%; carbon dioxide, 20.83%; water, 20.03%; silica, 0.40%; total, 99.96%.

The authorities in charge of the work were alarmed by these developments, and ordered the work discontinued. A commission was called to investigate the matter. It was found that 140 blocks had fallen into the water, and of these only 40 showed injury. Two kinds of damage were ap-

*Compare Lundteigen, Trans. Am. Soc. C. E., 1897, p. 135.

parent; (a) mechanical injuries, consisting of cracks, fractures on the edges, and in some cases complete breaking up of the blocks; and (b) chemical deterioration, shown in the formation of stalactitic growths and the peculiar milky liquid. These contained a large amount of magnesium hydrate, and proved that chemical action between the salts of the sea-water and the mortar had taken place.

Close inspection showed that the chemical action was most apparent at points where mechanical injuries had allowed the penetration of the sea-water into the interior of the blocks. It was also found that only the newest blocks, prepared late in the foregoing autumn, had suffered injury, and that all of the older blocks, 2,500 of which had been placed in the sea during the previous 6 years, were sound in all respects, and had perfectly resisted the action of the sea-water salts.

In consequence of these observations the work was resumed two years later and completed according to original methods. Twenty-five years have now passed since the work was begun, and up to the present time all the blocks appear to be in faultless condition. Some of those which had been least injured were put back into the water after removing the fractured portions; these also have proved perfectly durable, and are not to be distinguished from the others so far as any subsequent damage is concerned. This example shows that we have at our command means for the perfect protection of concrete work from injury by sea-water. These are:

1. Use of good, thoroughly-tested cements.
2. Correct composition of mortar.
3. Careful preparation of the concrete, with sufficiently heavy ramming in the molds to produce a dense mass.

Another noteworthy case is that of the constructions in the harbor of Yokohama, which occurred 20 years later than that at Odessa. Defects in the concrete blocks, similar to those observed above, were found, but were proved to be due to the use of too poor a mixture (1 to 3), insufficient working of the mortar, and failure to protect the blocks from the heat of the sun during their preparation. From the latter cause, shrinkage cracks, due to too rapid drying out, were formed, and these allowed the entrance of sea-water into the blocks and favored its destructive action. After full investigation the work was continued with mortar of the same cement with 2 parts sand, and with special precautions against injury by the heat of the sun.

Professor Schuliatschenko went on to say that he did not share the doubt expressed by Dr. Michaelis in regard to the durability of Portland cement concrete in sea-water, and that in his opinion there is no need of the addition of trass or any other admixture. It is possible that trass may improve and cheapen cement concrete, but we have no evidence, taken from long experience in actual work on a large scale, in regard to the durability of such mixtures, as we have in the case of ordinary Portland cement concrete.

Herr Dykerhoff, referring to the formation of a protective coating on concrete, stated that his laboratory tests of cement-lime mortar and trass-mortar in sea-water are now 4 years old. In from one to two years these were distinctly attacked. The action seems to have gone no further, owing to the formation of a coating of unknown composition, and briquettes of cement 1, lime ¼, sand 4, are now actually stronger than those of cement 1, sand 4, without the addition of lime. In this connection Herr Dykerhoff gave an abstract of a paper by Candlot on the action of sea-water on mortars, published in the French journal "Le Ciment" in 1896.* This article contains an interesting review of the results obtained in this field by French engineers during the past 40 years. Candlot's paper is, in substance, as follows:

The investigations which have been carried on at the harbor of La Rochelle since 1856 are of great interest, since they have been made under practical conditions and extend over a period of 40 years. The first series of experiments was begun in 1856 with blocks 24 ins. square. These were made from hydraulic limes from various sources, natural cements from Poully and Vassy, artificial puzzuolanas mixed with various kinds of lime and sand, mixtures of cement and lime, and, finally, from the trass of Andernach with lime and sand. These blocks were placed in the sea at various times from 1856 to 1875, in such a manner that they were exposed to air at every ebb-tide. Nearly all of the blocks disintegrated completely, sooner or later, and most of those which remained were strongly attacked. Only a few blocks made from Portland cement concrete were included in the tests; of these the blocks made from English cement (1857), and French cement (1859) remained in very good condition. Blocks of neat Portland cement had disintegrated. The most durable blocks were made with a mortar of cement with 1 or 2 parts sand.

In 1880 a new series of tests was begun, with concrete blocks 16 ins. square on the face, made from Teil hydraulic lime. Of 32 of these blocks, six had disappeared in 1895, and the remainder were well advanced toward destruction. In 1880 a series of tests of concrete blocks, 16 ins. square on the face, made chiefly from limes and French and foreign cements, was begun. These were sunk in a basin connected with the sea, the water of which changes itself twice daily. Of 26 blocks made from French natural cements, 7 have gone to pieces.

Tests of slag-cement were begun in 1891. Of 20 blocks immersed from 1891 to 1893, 14 are in process of decomposition; 4 others made in 1894 and 1895 are still in good condition. Of 31 blocks made from Portland cement, 1881 to 1892, 22 are still unattacked, while 9 have begun to disintegrate.

According to Viennot, the following conclusions may be drawn from the above experiments: 1. Mortars made from hydraulic lime begin to decompose in sea-water, in most cases, within one or two years, and are completely destroyed within 15 years or less. 2. Concrete shows greater resistance than masonry laid up in cement, owing to the greater density caused by stamping. 3. Quick-setting natural cements begin to decompose after 5 to 8 years in sea-water, and are then quickly destroyed. 4. Slow-setting cements may also decompose after 6 to 8 years, but may last 38 years or longer, as observed above, without decomposition. 5. The most resistant mortars are those made with 1 part cement and 1 or 2 parts sand.

One fact is clearly brought out by the experiments at La Rochelle; namely, that no hydraulic material at present known is capable of resisting the action of sea-water if the latter penetrates to the interior of the concrete. Further, no cements should be used in sea-water which contain free lime in an unslaked condition. In the case of artificial, carefully-made Portland cements this condition is abundantly fulfilled, as may be proved by simple tests. Since all mortars are decomposed when penetrated by sea-water, the efforts of engineers must be concentrated upon the task of producing mortar of the greatest density and impermeability. In this respect mortars made from Portland cement are far in advance of all others. This cement possesses a greater specific gravity, requires less water in mixing and is capable of combining with a larger amount of water than any other hydraulic material.

A perfectly dense mortar cannot, however, be obtained by the use of an amount of cement sufficient to completely fill the voids in the sand. A certain percentage of voids will always remain, due to air-bubbles which remain enclosed in the mortar. The porosity of the mass varies also greatly with the amount of excess of water used in mixing. Portland cement requires about 25% water to produce a plastic mass, and will take up in hardening 18 to 20%. Natural cement, slag cement and hydraulic lime require 30 to 40% water in mixing, and will take up in hardening only 5 to 10%. From this it is evident that the voids due to excess of water amount to almost nothing in the case of Portland cement, while with other hydraulic materials they may reach 30 or 40%. A mixture of 1 part Portland cement with 2 parts coarse sand showed only 9% of voids. In well-rammed concrete the voids are much less.

It may appear surprising that in the above experiments at La Rochelle blocks of pure cement were destroyed, while those of 1 part cement with 2 parts of sand stood well. Pure (neat) cement is very dense, and soon becomes entirely impermeable. It becomes, however, exceedingly brittle, and breaks under very light strain. After four years in sea-water, neat cement showed a strength of only 91 lbs. per sq. in., while the same cement, with 1 part sand, showed 778 lbs.

Dr. Michaelis proposes to solve the problem of the preservation of cement in sea-water by the addition of trass or pozzuolana, which shall combine with the lime set free in the hardening. He claims that the addition of trass increases the strength of Portland cement concrete, and greatly diminishes the action of sea-water. It is, however, difficult to draw conclusions which are of value in practice from laboratory experiments of this kind. Alexandre found that the sand which with cement gave the best results in sea-water was composed of limestone fragments. Feret found a given cement to give, after 1 year in sea-water, in the proportion of 1 to 3:

With normal quartz sand	366 lbs.
" crushed marble	562 "
" crushed trass	491 "

In this case there is no possibility of chemical action between the marble and the lime which the cement liberates in hardening, and yet the marble gives higher results than the trass. All these experiments show that the benefit obtained from certain additions to cement may result from purely mechanical causes, and there is nothing to prove that the addition of substances which may form chemical compounds with the cement is of benefit. Is the lime set free in the hardening of cements a source of danger? Should a substance be added which will combine with this lime? Do pozzuolanas have a good effect? None of these questions have as yet been satisfactorily answered.

Meanwhile, the faultless behavior of Portland cement mortar which has been immersed in the sea for more than 40 years proves that the addition of pozzuolanas is unnecessary. One fact, at least, is well established; namely, that the mortar must be as dense as possible. The question of the greatest importance is, therefore, the choice of the sand. Sand which contains much fine material must be avoided, and if none other can be obtained, the proportion of cement should be increased. It should, however, be remembered, that a relatively poor mortar made with coarse sand is to be preferred to a rich one made with fine sand.

Dr. Michaelis stated the results of his own experiments, which appear to prove the beneficial effects of trass, especially in poorer mixtures of cement and sand. For example, a mixture of Portland cement 1, fine sand 1, normal sand 8, was compared with a mixture of Portland cement 1, trass 1, normal sand 8. The trass mortar showed four or five times the strength of the other mortar, and after long periods in salt water was stronger than the same mortar in fresh water; while the mortar without trass began to decompose in salt water after 180 days. Dyckerhoff presented a series of experiments on the same subject, which appear to confirm, in general, the claim that trass improves the strength of cement mortar, kept in sea-water. The question of appropriating a sum of money toward the cost of the proposed experiments on this subject was left with the officers of the association.

Report of the Committee on Uniform Testing Apparatus.—After discussing some unimportant modifications in mixing apparatus, reference was made to the proposed official test of cement with 1 part sand as well as with 3 parts. It was found that the results obtained by different members of the committee in testing the same cement with 1 part sand varied greatly, while tests with 3 parts sand showed very satisfactory agreement. It was recommended, therefore, that the test with 1 part sand be not included in the official standards.

Careful tests of the Schmelzer mixing pan, for preparing the mixtures of cement, sand and water for cement tests, were made by the committee. The need of a suitable apparatus for this purpose, which should avoid the errors and variations due to hand-mixing, has long been felt. The results obtained with the mixing pan proved much more uniform than those given by hand labor. With

*Thonindustrie Zeitung, 1896, Nos. 14 and 15.

the mixture, cement 1, sand 3, the greatest difference in tensile strength among 15 briquettes was 98 lbs. with hand labor and only 47 lbs. with the pan. In view of the fact that the committee were wholly inexperienced in the use of the pan, and that no definite rules for manipulating it had been agreed upon, the improvement shown in the results is very significant. It was pointed out that in making several hundred tests per day, it is quite impossible for an operator mixing by hand to do equal justice to all; late in the day, when he is tired, the work will necessarily be less thorough. An improved mixing pan, capable of preparing about 8 lbs. of mortar at each operation, was shown at the meeting. In the opinion of the committee the introduction of this apparatus marks a distinct advance in the testing of cements.

A series of tests were made by the committee to determine the length of time briquettes of cement with 3 parts sand should be allowed to remain in the molds. Contrary to the general belief, it was found that briquettes taken from the molds as soon as made gave the most uniform results, and the longer the briquettes were left, the greater variation was observed. The committees on the influence of magnesia, also the committee on tests for constant volume and time of setting, presented reports of progress, but deferred giving detailed statements until next meeting.

Report on the Corrosion of Cement Reservoir Linings by Water Containing Carbonic Acid.—Herr Schiffner and Herr Schott reported cases in which the cement lining of reservoirs had been considerably corroded in the course of several years. Analysis of the water in question showed the presence of a high percentage of free carbonic acid. The walls of the reservoirs were found covered with a reddish deposit, containing iron oxide and alumina, with but little lime. Dr. Kosman attributed the corrosive action of the water to the presence of considerable quantities of magnesium chloride, rather than the action of carbonic acid.

FLYWHEEL EXPLOSION AT THE POWER HOUSE OF THE TACOMA RY. CO., TACOMA, WASH.

By A. McL. Hawks.

The following description of the somewhat serious flywheel accident which took place on July 11, at the power house of the Tacoma Ry. Co., at Tacoma, Wash., may prove interesting for comparison with previous accidents of this character. The primary cause of the disaster was the breaking of one of the brass arms attached to the sliding collar on the governor. This let the valve stem drop, and under the increased steam pressure the engine immediately began to gain speed. The accident occurred at 1 p. m., on Sunday, July 11, while the engine was working under a somewhat heavy load as all the suburban lines were running Sunday excursion cars. The engineer, who was in another part of the room, heard the rod snap and, seeing the engine speeding up, hastened to shut the steam off by means of the hand wheel. This wheel was located in a very bad position, as any one operating it had to stand directly in line with the flywheel and beneath the belt by which this wheel drives the counter shafting.

By the time the engineer had partly cut off the steam, this belt was badly frayed by the terrific strain put on it by the racing engine. And, too, the cable engine, which was "in clutch" on the axle shaft with this engine was giving way on its bed plate. So, when he had the valve half closed, seeing that the speed of the engine was gaining and being disconcerted by the snapping of the frayed edges of the belt, the engineer sought safety in flight. He had scarcely reached a place of safety when the explosion (which sounded like the bursting of a boiler) occurred. The time interval between the first break and the final one was about three minutes. When the dust had cleared away the scene of the accident was as shown by Fig. 1. The bright spot showing through the top opening is a break in the roof made by three large pieces which flew straight up and came down through the same hole, landing within a few feet of their starting point. The pieces flying through the front of the building traveled distances ranging from a few feet to 400 ft. The width of their path was very narrow, nothing striking more than 15 ft. out of line, although some pieces bounded erratically and finally stopped some considerable distance from the line.

The sketch, Fig. 2, gives a better idea of the paths of flight of the pieces than can be obtained in any other way. The wheel seems to have burst into three parts, divided somewhat as follows: One arm and about a quarter of the rim flew up through the roof; two arms and a quarter of the

Fig. 1.—View of Portion of Power House of the Tacoma Ry. Co., Damaged by the Bursting of a 40-ton Flywheel.

rim flew out through the front of the building; four arms and nearly a half of the rim piled up in the back end of the wheel pit. Besides these major divisions several small pieces of the rim flew through the engine room, knocking down a steam pipe, entirely destroying the 4-ft. pulley on the counter shaft, injuring two dynamos, and about half of one arm remained in place. The other arms are broken off close up to the hub plates as if a Samson blow had been given each of them at that point.

The rim broke into strips varying from 1 ft. to 8 ft. of the length of the circumference and entirely across the face of the wheel. As these pieces show from 250 to over 360 sq. ins. of clean fracture in the two faces, some idea of tremendous strain may be gained. The normal speed of the engine was 62 revolutions per minute. How far this was exceeded is not known owing to the excited condition of the few who were present through only a part of the racing.

The engine was built by the Frick Engine Co., of Waynesboro, Pa., and was rated by the builders at 750 HP. under 80 lbs of steam. But it had been run under loads estimated as high as 900 HP. The flywheel was built up of two heavy hub-plates keyed to the shaft. Between these plates and bolted through them were the arms, of cruciform shape, 8 × 16 × 2 ins. thick. The rim was 2½ ins. thick, 4 ft. 8 ins. wide, reinforced by two ribs on the back, 2 ins. thick by 6 ins. high, and also reinforced by heavy shoulder plates at the points where the arms were bolted to the rim. The diameter of the wheel was 25 ft., and the total weight 40 tons. Of the engine, practically the only parts left in place and in good condition are the steam chest and the bed plate. Even the piston rod is bent almost beyond repair.

PROGRESS OF THE IRON TRADE IN THE THREE LEADING COUNTRIES OF THE WORLD.

The annual "Statistics of the American and Foreign Iron Trades," recently published by the American Iron and Steel Association, contains an interesting table of the production of pig iron in the United States, Great Britain and Germany, for each of the years 1869 to 1896, inclusive. We give the table in condensed form below, and have plotted from it the accompanying diagram. The condition of the iron trade is commonly considered as a "barometer" of industrial progress in general, and the diagram reveals in a striking manner the peculiar features of this progress in the three countries named, during a period of 28 years.

Pig Iron Production of the United States, Great Britain and Germany, from 1869 to 1896, Inclusive.

Year.	United States, thousands of gr'ss tons.	Great Britain, thousands of gr'ss tons.	Germany and Luxemb'rg, thousands of met. tons.
1869	1,711	5,446	1,409
1870	1,665	5,964	1,391
1871	1,707	6,627	1,564
1872	2,549	6,742	1,988
1873	2,561	6,566	2,241
1874	2,401	5,991	1,906
1875	2,024	6,365	2,029
1876	1,969	6,556	1,846
1877	2,067	6,609	1,933
1878	2,301	6,381	2,148
1879	2,741	5,995	2,227
1880	3,835	7,749	2,729
1881	4,144	8,144	2,914
1882	4,623	8,587	3,381
1883	4,596	8,529	3,470
1884	4,098	7,812	3,601
1885	4,045	7,415	3,687
1886	5,683	7,010	3,529
1887	6,417	7,560	4,024
1888	6,490	7,999	4,337
1889	7,604	8,323	4,525
1890	9,203	7,904	4,658
1891	8,280	7,406	4,641
1892	9,157	6,709	4,937
1893	7,125	6,976	4,986
1894	6,657	7,427	5,580
1895	9,446	7,703	5,465
1896	8,623	8,563	6,375

Considering the statistics of Great Britain first, it will be observed that in 1869 its production of pig iron was more than three times that of the United States, and nearly four times that of Germany. Since 1869 the diagram shows that the history of the trade may be divided into two distinct periods; one of 10 years, from 1870 to 1879, inclusive, and one of 17 years, from 1880 to 1896, inclusive. In the first period the annual production averaged 6,380,000 tons, with a maximum variation from this average in any one year not exceeding 6%. In 1880 a great increase in the production took place, and for the second period of 17 years, it averaged 7,750,000 tons, with the greatest variation in any one year of 10.6% above and 13.5% below this average. The year of maximum production was 1882, when the total of 8,587,000 tons was reached. Very nearly the same figure, or 8,563,000 tons, was reached in 1896. For the last 17 years, or since 1880, therefore, in the production of pig iron Great Britain has done no

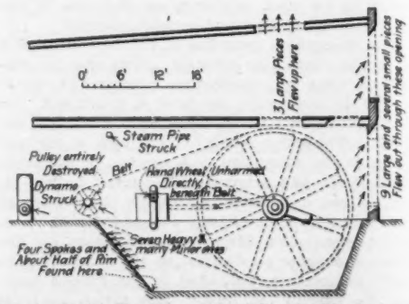
0' 6' 12' 18'
3 Large Pieces Flew up here
Steam Pipe Struck
Pulley entirely Destroyed
Belt
Hand Wheel Unharmed
Directly beneath Belt
Dynamo Struck
Four Spokes and About Half of Rim Found here
Small Heavy Fragments Found here
9 Large and Several small pieces Flew out through these openings

Fig. 2.—Sketch Showing Action of Flywheel Explosion at Tacoma, Wash.

more than "hold its own," while the production in the United States has increased 225%, and that in Germany (including Luxemburg) 234%.

In the United States the history of the production of pig iron has been one of "leaps and bounds," with occasional periods of depression. The first leap was in 1872, when the tonnage increased nearly 50% over that of 1871. From 1873

to 1876 the tonnage decreased from 2,561,000 to 1,869,000, then followed an increase during the next six years to 4,623,000 in 1882, and a decrease in the following three years to 4,045,000 tons in 1885. The five years following 1885 showed the most remarkable increase in the history of the trade, the figures for 1890 being 9,203,000 tons, an increase of 127% above that of 1885, and nearly 100% above that of 1882, the previous maximum year. The next year, 1891, showed a decrease of 10%, but in 1892 the figures of 1890 were within 0.5% of those of 1890. Then followed the two years of extraordinary depression, 1893 and 1894, in the latter of which the production was only 6,650,000 tons, or nearly 38% below that of 1890. A great recovery took place in 1895, the production, 9,446,000, exceeding that of any previous year, but a falling off of nearly 9% took place in 1896, the production for the year being 8,623,000 tons. During the first half of the present year the production, according to the monthly figures given by the "Iron Age," has remained nearly constant at the rate of about 8,750,000 tons per year, but the present improved business prospects make it probable that the total figures for this year will exceed 9,000,000 tons.

If we omit the two years of extreme depression, 1893 and 1894, the production for the other five years, between 1890 and 1896, inclusive, averages 8,942,000 tons, with a variation not exceeding 8% in any one year. It is a question for the future to determine whether the approach to a constant rate of production indicates that the iron trade of the United States has reached a condition similar to that which has characterized the iron trade of Great Britain for the last 17 years, in which the best that the trade can be expected to do is to "hold its own," or whether these years represent a temporary condition similar to those which existed in the five years, 1874 to 1878, inclusive, and in the two years, 1884 and 1885. If the latter is true, then we may expect an enormous increase in the production in the next few years, similar to the increase which took place in each of the periods following previous years of depression.

The history of the trade in Germany has been in marked contrast to that in either Great Britain or in the United States. Showing neither the uniformity in rate of production of the former nor the "leaps and bounds" of the latter, its production has increased at a remarkably uniform rate. Drawing a straight line on the diagram from 1869 to 1895, it will be seen that the plotted line of annual production does not vary from this straight line more than 750,000 tons in any one year of that period, and not over 200,000 tons in any one year of the nine years from 1887 to 1895, inclusive, the very years in which the trade of both Great Britain and the United States showed the most extreme fluctuations. The annual increase of production in Germany shown by this straight line is equivalent to an average increase of 150,000 tons per year. In 1896 this constant rate of increase was departed from in a most unusual manner for Germany, the increase above 1895 being 910,000 tons, a greater increase than was ever shown by Great Britain, with the exception of the single year 1880. It is notable that this increase did not take place at the expense of the trade of Great Britain, for the production of the latter also increased 860,000 tons in 1896. The fact that such a large increase took place simultaneously in the production of the two leading exporting nations indicates a great increase in the last year in the iron consumption of the world outside of the United States. The increase in the world's production prior to 1896 is also shown in the following figures condensed from a table given in the report of the American Iron and Steel Association:

The World's Production of Pig Iron.

Year.	Gross tons.	Year.	Gross tons.
1840.....	825,000	1879.....	13,960,000
1839.....	1,825,000	1880.....	17,950,000
1850.....	4,750,000	1885.....	19,100,000
1856.....	7,000,000	1890.....	27,157,000
1866.....	9,300,000	1893.....	24,813,000
1872.....	13,925,000	1895.....	28,871,000

The year 1896 was a notable one in the history of the iron trade in the United States in showing a great increase in its exports of iron and steel. The total exports of pig iron and iron and steel products, such as rails, plates, nails, wire, etc., amounted in 1896 to 203,347 tons, against only 89,389 tons in 1895. The figures are as yet, however, relatively insignficant as compared with the figures of production of pig iron, being only 2½% of that production in 1896, and less than 1% in 1895. The exports are also less than the imports of heavy iron products, which were 378,208 tons in 1895, and 265,000 tons in 1896. They were not enough in 1896 materially to increase the production in the United States, which decreased, notwithstanding the increase of exports, nor to decrease the production of Great Britain and Germany, which increased in spite of them. The export of American pig iron and steel rails to Europe, which began in 1896, was largely due to the facts that the trade was prosperous and prices relatively high in Europe, while trade was depressed and prices unusually low in this country. Whether this export trade can continue after a revival of business in this country increases the prices of iron and steel is as yet doubtful.

In this same connection our German contemporary "Stahl und Eisen" lately discusses the development of the manufacture of cast steel by the various producing nations between 1865 and 1896. This development has been uninterrupted since the discovery of Bessemer, and the later processes, and especially the Siemens-Martin, have

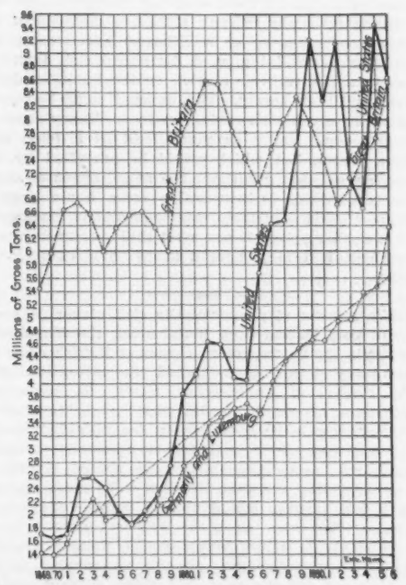

Diagram Showing the Relative Production of Pig Iron in the United States, Great Britain and Germany, from 1869 to 1896, inclusive.

only added impetus to the general growth. While during the first twenty years the Bessemer process produced in all about 20,000,000 tons of cast steel, the annual production by the two processes now touches 16,000,000 tons. The following table gives the annual production in metric tons for the four principal producing nations, though our contemporary extends this to include Austria, Russia, Belgium, Sweden and Spain:

Year.	United States.	England.	Germany.	France.
1865.....	13,848	225,000	99,543	40,574
1870.....	68,057	286,797	169,951	94,386
1875.....	396,165	723,605	347,336	256,903
1880.....	1,267,700	1,320,561	624,418	383,894
1885.....	1,739,883	2,020,450	893,742	553,839
1890.....	4,346,932	3,637,381	1,613,783	581,998
1895.....	6,212,671	3,312,115	2,830,468	714,523
1896.....	5,600,000	4,200,000	3,437,981	883,508

In the original table Austria is credited for 1896 with 878,834 tons; Russia made 574,112 tons in 1895, and Sweden for the same year produced 197,177 tons. In 1896, Belgium made 508,755 tons, and Spain 104,577 tons. The industry took its first great start in 1875-80, with England always leading until 1890, when the United States surpassed England's output nearly one million tons, and has remained ahead since. But Germany also presents a very steady growth in production and promises to catch up, if not exceed England's output in a very short time. On the graphic exhibit presented by "Stahl und Eisen" the lines for the United States and England show a succession of mountain peaks, representing the fluctuations in yearly production. But the line for Germany, as in the case of pig-iron, is an exceedingly steady one since 1883. Russia, Austria and Belgium have also advanced very rapidly.

AUTOMOTOR CARS OF THE SERPOLLET SYSTEM, USED ON THE RAILWAYS OF WURTEMBERG.

Last December some practical tests were made of an automotor car, built for special service in the suburbs of Stuttgart, and intended to connect that city with a number of industrial centers lying from 7 to 9 miles distant. It is the intention of the company to use these cars on the ordinary railway tracks, running them between the normal trains. These cars are light in construction; have four wheels only, with the rear axle placed well towards the center, and they will seat 32 passengers each. Light baggage can be carried on a roomy rear platform, and a center aisle admits of free circulation. When occasion demands, each automotor car can pull an additional car of the ordinary design, but unprovided with a motor. They are designed for a speed of 22 miles per hour on a level and 15 miles on a grade of 5.3 ft. per mile. The total weight of the car, fitted for work, is about 37,400 lbs., of which 26,400 lbs. is upon the front, or driving axle, and the remainder upon the rear axle. Each automotor is supposed to be able to haul another car with a load of 13 tons.

The motor used is of the ordinary Walschaert locomotive type, with driving wheels 3.28 ft. diameter. But the steam is supplied by a Serpollet generator placed on the front platform. This generator is of the vertical type with two distinct batteries, made up of eleven stages of four elements each. Eight of these stages are formed of tubes of a U-section; the two lower stages have tubes of a circular section with interior mandrels, and the upper stage is made of cylindrical hollow tubes. The heating surface of the tubes exposed to the heat gases is equivalent to 120 sq. ft., and the grate surface is equal to 4.9 sq. ft. The upper tubes of the generator are joined so as to form a steam collector from which the steam passes to the motor cylinder. The pressure capable of being generated in this Serpollet device is indicated by the fact that the tubes are stamped for 94 atmospheres, and are able to resist 200 or more atmospheres. In practice the maximum pressure used will be about 213 lbs. per sq. in.

In the experiments made last December, a working pressure of 113 lbs. per sq. in. easily maintained a speed of 30 miles per hour on the level, and over 22 miles per hour on a 3-mile grade of 5 ft. per mile. On the level track this same automotor hauled a load of ordinary freight cars aggregating a total weight of 94 tons. Since last January these cars have been in regular service between Stuttgart and Tuebingen, Rottenberg and Reutlingen, averaging about 120 miles per day, at an average speed of about 24 miles per hour. The briquette fuel used in summer amounted to from 2½ to 3 kilos. per kilometre run, according to the load carried. The estimated cost of fuel, lubricants and waste for this period was 7 pfennigs per mean car-kilometre, equivalent to about 2.8 cts. per car-mile, a sum which the company hopes to decrease.

THE MESA ENCANTADA, IN NEW MEXICO, was successfully ascended by Prof. William Libbey, of Princeton College, on July 23. This isolated sandstone rock is found to be 550 ft. high, above the surrounding plain, and the top is 6,750 ft. above sea-level. The superficial area is about 15 acres. Contrary to popular belief, Prof. Libbey found no traces of human habitation or evidence that it had ever been ascended previously. A ¼-in. line was thrown over a projecting point by a 2½-in. life-station mortar. After a second trial, and with this small line a hawser was finally raised and fitted with a hoisting tackle and chair. The ascent was made in 2½ minutes. On the top he found water in pools, from the rain, sparse vegetation, similar to that of other mesas and buttes in the vicinity, and animal life in profusion. The current tradition is that this mesa was once accessible at a single point and that the top was occupied by an old Indian village. This is now disproved.

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We again transgress our rule against the publication of "continued stories" to present to our readers a very valuable paper on the design of centrifugal pumps, by Mr. John Richards, of San Francisco. Mr. Richards is one of the foremost experts in the world on this subject, and the article should attract the attention of all who are interested in this branch of engineering. The concluding portion of the paper, which we shall give next week, brings the subject down to the present date, examples of the most recent pumps being given. We desire especially to call the attention of engineering students to the question of the design of centrifugal pumps as being one which offers problems for study which have been less fully investigated than those in almost any other branch of engineering. The design of centrifugal pumps has progressed by a sort of evolution during the past fifty years, but during that long period there has been no satisfactory attempt to reconcile theory with practice, and the construction of these pumps has, as a rule, not been based on rational study, but almost entirely on the method of tentative experiment. There have been consequently developed neither standards of form nor standard formulas and rules for designing, such as are common in most branches of constructive engineering. How to design a bridge, a locomotive, a boiler, a marine or stationary engine, or an electric motor, is a problem, the knowledge of which is common throughout the world. The theory of such a problem is taught in the schools, and the theory and practice are in close agreement. In these constructions also there is generally a standard type, which is accepted for long periods of years as being almost incapable of improvement, except in minor details. Examples are the Corliss engine, the American locomotive, the Scotch marine boiler, and the vertical triple expansion marine engine. How to design a centrifugal pump, however, is a problem that few engineers have ever solved, or even studied. The literature upon the subject is extremely meagre, and what there is of it is mostly unsatisfactory. There has been no treatise written upon it which will compare with any one of a dozen treatises on the steam engine, and the papers on the subject which have been presented to engineering societies are of the most fragmentary character. The articles of Mr. Richards do not pretend to treat the subject from the standpoint of the scientific investigator of a mathematical turn of mind, but entirely from that of a practical builder and designer; and they contain a great variety of important practical data which may be used by the student as a basis upon which to build future study and research.

We illustrate elsewhere in this issue a novel electric motor-carriage, which, like the familiar trolley car, depends upon a line wire for its supply of electric current, but runs along the highway instead of upon a track. Considered as a solution of the motor vehicle problem, this invention seems to possess little merit, for manifestly neither those who use the roads for pleasure or for business can be confined to a regular fixed route for that journey. But considered from another point of view, it is entirely possible that this invention may prove of very great practical importance.

There are hundreds of places in the suburbs of cities where there is an urgent demand for passenger transportation facilities, and yet the volume of traffic is too little to support an electric railway line, even if the construction of its track along the streets would be tolerated. What is wanted is some system of cheap transportation to radiate from the railway station a distance of a couple of miles or so in different directions, and provide those living at a distance quick transit between the railway station or the business district and their homes. This demand could be supplied by a vehicle running on the ordinary roads, which could carry as much load as a team of four horses, but which would be propelled by a mechanical motor without the noise, expense, and nuisance which is inseparable from horse traction. If this new motor-carriage or one designed on a similar principle can meet these requirements, we believe it may have a large field of usefulness.

The reports of phenomenally rich placer deposits of gold having been found along the Klondike River in the northwestern corner of British America have doubtless attracted the attention of the readers of Engineering News, in common with most people, during the past fortnight. While there seems to be good reason for believing that the richness of these fields is unusually great, many of the stories which have gained circulation regarding the vast fortunes to be made there in a few months are doubtless gross exaggerations. However, as these wild statements are very likely to allure many people, among whom some of our readers may possibly be included, into setting out for the new gold fields without adequate preparation, it is well to call attention briefly to the nature of the country and the conditions of life which will have to be encountered by these fortune-seekers. As is well known, the Yukon country in which these new diggings are located has an almost Arctic climate, the winters being extremely long and severe, and the summers, though quite warm, being correspondingly short. Nature furnishes almost nothing for the support of life, all food and other supplies being necessarily shipped into the country during the few summer months by a slow and tortuous steamer route up the Yukon River, or on the backs of Indian carriers, or on those of the miners themselves. From Seattle, Washington, by the Yukon River boats, the journey requires 40 days, and the route is passable only in the summer months, while by the overland route the journey takes far longer. The result of this is that the cost of living is enormous at all times, and suffering for the want of food at some portions of the year must be universal, while death by starvation in the diggings is no remote possibility. Thus far the stories that have reached us from the gold fields have been altogether about the riches to be gained; but we may surely expect tales of disappointment and suffering later. The history of all rich gold discoveries, whether in California, Australia, Colorado or Cape Colony, has shown that, while a few gain fortunes, very many more lose all their substance and often their lives or health. It must not be forgotten, also, that in all these great gold fields nature has on the whole been far less inhospitable than she has in the Yukon territory. It is too much to expect that everyone will be restrained from seeking the Klondike diggings because of these considerations, but at least any one should be able to see the necessity of going well provided with money, clothing and supplies, which will surely be needed even if they chance to be successful in their search for gold.

THE ACTION OF SEA WATER UPON HYDRAULIC CEMENTS.

The effect of sea water upon hydraulic cement concrete, the exact causes for the destructive action noted in many places, and the remedy for the admitted evil have long furnished a fruitful topic for discussion by engineers. Many theories have been advanced explaining both cause and effect; but as these theories are too frequently based upon laboratory experiments alone, it is now generally admitted by engineers that the only safe guides in this connection are actual practice and long time exposure to the action of salt water, coupled with the most careful and intelligent selection and use of materials. In other words, theories are well enough, but to be accepted they must be founded upon and agree with the results of experience extending over a long period of time.

In this connection, the report of the Association of German Portland Cement Manufacturers, elsewhere given in this issue, has an especial interest on account of the very considerable space devoted to the action of sea water upon hydraulic cement. This association is now conducting an elaborate series of experiments in this direction, at the Island of Sylt, with Portland, Roman and Pozzuolana, or slag cements, and the tests already made have given very valuable results. While all of their conclusions upon the resistance of hydraulic cements to the action of sea water naturally favor Portland cements, these conclusions are seemingly well founded and may be summed up as follows:

In the first place, as it is now very generally admitted that no hydraulic cement known will successfully resist sea water if this water gains access to the interior of a concrete block, density and imperviousness in the mass are first requisites. The association claims that this density can only be obtained by the use of Portland cement mortar in the proportion of one cement to one or two of sand. The reason given is that Portland cement mortar possesses great specific gravity, and requires only about 25 per cent. of water to form a plastic mass, and takes up from 18 to 20 per cent. of this water in hardening. Natural cement, hydraulic lime and slag cements, on the other hand, usually require from 30 to 40 per cent. of water to mix them properly, and they only take up from 5 to 10 per cent. of this water in the hardening process. The choice of sand is also most important, and experience has shown that sand containing much fine material should be rejected, and that a relatively poor mortar with coarse sand gives better results than a richer mortar with fine sand. The table given in the report also shows that the higher or lower percentage of alumina in Portland cement seems to bear no relation to the resistance of the cement to salt water. As compared with immersion in fresh water, the salt water exposure gives lower results in each case; but the ratio between the two seems to be about the same, whether the percentage of alumina is 5 or 8.5.

The views of Dr. William Michaelis, so vigorously attacked by some of the members of the association, were first advanced in 1882 and presented in full in 1896, in the Proceedings of the German Society for the Promotion of the Industrial Arts. The animus of the opposition can be better understood when it known that Dr. Michaelis defended the use of lime of Thiel in sea works, and claimed that, when properly applied, it had behaved much better than Portland cement under similar exposure to salt water. But his chief contention was that Portland cement, as now made, contained too high a percentage of lime; with the result that a larger portion of hydrate of lime remained free and was striving for saturation with something. If left to itself this free lime brings about unstable conditions in the mass by reacting upon the mag-

nesium sulphate of sea water and causes destructive action in the concrete; it exerts strong pressure and induces molecular changes. He sums up by asserting that any hydraulic binding media is unsuitable for maritime structures which contains more lime than is needed for the formation of stable hydro-silicates and aluminates; and in both of these compounds the stability increases in an inverse ratio to the percentage of lime present. He then suggests that hydraulic limes and Portland cements overloaded with lime can be improved by adding some substance, such as trass, which contains hydraulic silica and makes true cement by taking up the otherwise objectionable excess of lime. The association early contended that standard Portland cement needed no so-called improveing mixture; though Herr Dyckerhoff, in the report given, advances experiments that seem to confirm the claim that trass improves the strength of cement mortar used in sea water. Prof. von Tetmajer has also published his observations on the admixture of other substances with Portland cement, showing an actual increase in tensile and crushing strength, with a much less density than that of Portland cement. In any event the contention of Dr. Michaelis was of sufficient force to induce the association to empower their officers to devote money to further investigation of his claim.

Dr. Michaelis, with the others, says that imperviousness, or closeness of grain in the concrete, is a very important consideration in exposing hydraulic cement to salt water. Magnesia, formed by the action of sea water on these cements, was formerly accused of causing their destruction. Dr. Michaelis denies this, as have other authorities before him, and says that this magnesia is really a protection, as under the action of hydrate of lime on sulphate of magnesia the unsoluble hydrate of magnesia is formed, which aids in closing the pores and increases imperviousness. The real destructive agents, says this authority, are the sulphuric acid and the soluable sulphates in the sea water acting upon the free lime in the cement. The formation of sulphate and aluminate of lime implies an immense increase of volume and a consequent total destruction of all cohesion. This action separates the mortar grain by grain and finally leaves an incoherent slime—the milky exudation noted in concrete masses destroyed by contact with sea water.

Much of the old-time misapprehension about the action of magnesia in concrete exposed to sea water arose from the failure to note that magnesia in cement and magnesia as deposited from sea water, were two absolutely distinct matters. A very small percentage of magnesia in the original composition of a cement renders it dangerous, because the lime in the cement combines with the silica and alumina at a lower temperature than the magnesia, and the latter is consequently left in a free caustic state and expands when mixed with water. Mr. Henry Faija, a very competent authority on cements, believes that 3 per cent. of magnesia is the maximum for safety, though some cement containing 5 per cent. had tested well. The general percentage of magnesia in manufactured cement is about 1.8 per cent. On the other hand, magnesia, precipitated from sea water, is simply in the form of a hydrate or carbonate and is a perfectly inert material. Mr. Faija, in some experiments, passed sea water through concrete blocks under a head of 21 ft., and found that, after a time, percolation ceased, owing to the pores of the concrete becoming filled with a deposit of carbonate of lime and magnesia. He ascribes all failures of concrete under exposure to the effect of salt water to bad cement or to bad manipulation of the cement, and deprecates any condemnation of Portland cement as a material best suited for maritime works.

In summing up the evidence at hand, and noting the very large amount of cement concrete that has perfectly withstood exposure to the action of sea water for periods as long as 40 years, we may arrive at the following conclusions: The important requisites for permanent work of this character are—First, careful testing of the cements to be used to see that the proper care has been exercised in their manufacture; second, thorough mixing of the materials employed for concrete, after a choice of proportions has been made that will secure the densest mass possible; and third, a thorough ramming in mold, or in place, again with the view of compacting the mass. In addition to these precautions, measures may be taken to face the exposed work with a richer concrete mortar with the purpose of excluding salt water from access to the interior of the mass, through joints and by percolation under a hydraulic head. A protective coating on the concrete surface is always to be desired; and this coating may be secured by the use of better material at this point, as outlined above; or it may result from the formation of carbonate of lime, from the action of carbonic acid in the water upon the lime in the cement, and be aided by the deposit on this surface of extremely fine sand and clay and minute animal and vegetable organisms. In many of the cases noted chemical action has only followed mechanical injury to the blocks, permitting the access of water to the interior; and consequently the action of frost or of cracks resulting from too rapid drying must be guarded against.

Throughout the discussion of the German cement manufacturers, the makers of concrete for marine work are warned against the use of fine sand, but no explanation is given for this caution. The coarseness or fineness of the sand has a direct bearing upon the density or the porosity of the resultant concrete. The amount of gaging water that is absorbed as water of crystalization, is referred to, and the advantage of Portland over Roman cement and hydraulic limes, in this respect, is noted. But the sand added to Portland cement reduces this advantage somewhat; and a fine-grained sand requires a great deal of gaging water, whatever may be the nature of the binding medium. When the sand is coarse, on the other hand, and the percentage of cement high, then the water required for mixing is little more than would be required for neat cement. Candlot, in discussing this subject, says that in lime mortars the volume of voids, or the difference between the apparent and real volume of the set mortar, varies from 23 to 31 per cent. In cement mortars it varies between 13 and 31 per cent. A mortar made of 1,430 lbs. of cement and 35.3 cu. ft. of coarse sand, was found by Alexandre to contain only 9 per cent. of voids; while a lime mortar of like percentages gave 24 per cent. of voids.

Candlot uses the above to disprove the assertion of Dr. Michaelis that lime of Thiel resists the action of sea water better than Portland cement, while admitting that closeness of grain, or imperviousness, is a very important consideration. Candlot further adds that the density of lime mortar is little influenced by the proportions of the mixture, and says that, as a matter of fact, the rich lime mortars are generally more porous than those of an average degree of strength. In cement mortars, on the other hand, density increases with the percentage of cement and strength is also added. Mortar made of neat cement is the most dense of all and is quite impervious in time. But exposed to sea water this neat cement becomes exceedingly brittle after a few months and is rapidly destroyed. This destruction is now attributed to excessive crystalization, and, with an excess of lime, to the phenomena of expansion.

In a paper recently read before the Engineering Conference of the Institution of Civil Engineers, Mr. John Kyle, M. Inst. C. E., gave the following points upon the treatment of concrete in marine work, as the result of an experience extending over 40 years, in which time he had handled over 1,500,000 cu. yds. of hydraulic lime and Portland cement concrete: The chemical constituents of a sample for every 300 tons delivered were first examined and approved by an expert analyst. The cement was then bulked, 3 ft. thick, in a dry place upon a wooden floor raised 2 ft. from the ground; the cement was turned over weekly and only used after four weeks' storage, as he found the quality of the cement improved by keeping and turning. For fineness, he recommended 2,500 meshes to the inch; residue, 7½ per cent., and weight from 116 to 118 lbs. per bushel. Three briquettes tested from every 150 tons delivered should give, per 1½-in. square section, 350, 500 and 750 lbs. in two, four and seven days. He found that in practice coarsely and finely-ground cement tested about equally; and while the aged cement gave poorer day tests, the monthly and longer tests were better. Mr. Kyle claimed that fresh or salt water were equally suitable for mixing; provided, that only enough water were used to allow the mortar to leave the mixing machine in a stiff, pasty condition. Too much water, when evaporated, induced a honeycombed condition and favored the formation of what he calls drowned cement putty, which is pressed out by the water and leaves the concrete pervious to water.

With good ballast, Mr. Kyle says that the proportions may range from 6 to 8 parts of ballast to one of cement; or, if hand-broken road-material is used, four parts passing a 3½-in. ring and two parts passing a 1½-in. ring, with two parts of gritty sand and one of cement. The sand should not exceed twice the volume of the cement, and ballast and sand should be clean and free from all fine dirt. If the mortar is mixed by machine, it should undergo 16 to 20 revolutions; and if made by hand it should be turned twice dry and three times wet, to secure the proper pasty condition. When the mold is used Mr. Kyle insists upon this mold being filled in one day; with the sides slackened down in four days, and the block not lifted before four more days. Mr. Kyle truly says that all mass or bag-work, requiring the deposit of fresh concrete under water, is very uncertain in its results; as the film of drowned cement putty will always be present and bonded or monolithic work is practically impossible. About blockwork alone there is no uncertainty, though conditions may sometimes compel the use of the other methods. For this latter work he prefers blocks of from 20 to 50 tons weight, aged four to eight weeks before setting. The strongest blocks made by him contained clean ballast, or broken granite, with flat sprawls used as "displacers" laid in both directions and not closer than 6 ins. to each other.

This very condensed statement of the practice of an engineer experienced in the use of concrete in marine works is useful in itself, and is made further interesting by the statement of Mr. Kyle that not a yard of concrete laid by him has, to his knowledge, failed or deteriorated in quality by reason of the action of sea water. While some might insist upon a closer inspection of the cement, his practice, as here outlined, indicates that success will always follow the proper use of good materials; and it also generally follows, from the report of the German Association, and the recorded experience of many engineers, that the failure of concrete in marine work can usually be traced to bad materials or to bad practice in their manipulation.

LETTERS TO THE EDITOR.

The Failure of the Melzingah Dams of the Fishkill & Matteawan Water Co.

Sir: I have just read, with great interest, your very excellent and thorough report upon the late failure of the Melzingah dams. As I made a casual visit to the scene myself, I can corroborate the general accuracy of your report, in so far as my own comparatively superficial personal examination follows your very much more complete and detailed one.

I believe your theory as to the immediate cause of the catastrophe to be correct; namely, that when the upper dam gave way, the descending wave struck the embankment of the lower one before it reached the spillway, so that the relief which this latter might have afforded came too late, or rather did not come at all, for the dam had relieved itself, meantime, in its own way.

This fact—for fact I take it to be—raises an interesting point which I do not recollect seeing mentioned by any author. I mean the relative position of the spillway, so as to act always in the most efficient manner. We always seek a side overflow, in rock, when the topography of the site permits, as was done in the present instance in preference to one directly in line with the stream, and over the highest part of the dam itself, but this disaster shows that there is a dangerous feature involved by placing the overflow or spillway, "around the corner," and virtually below the dam. In this case the dam, to resist, would have had to be high enough and strong enough to meet and deflect the wave, and throw it around to the spillway. Possibly, had the wave reached the spillway first, it might have found a sufficient exit without topping the dam, but generally nothing but the best and strongest work can stand the test of the sudden release of a large volume of water behind it.

The upper dam gave way without this severe test, and simply on general principles. The water rose in the spillway and finally went over the top of the dam, simply because the top wasn't high enough to keep its head out of water. There is no use of having a capacious spillway if you let your embankment, either originally or by subsequent settlement, sink to within a few inches of the level of the lip of the overflow. No matter how long this latter may be, the water requires to rise to a sufficient head to carry it over as fast as it comes. If in achieving this head it rises over the crest of the dam, at least of such a dam as the one under consideration, total destruction follows as a mathematical sequence. The miserable apology for a center wall in the present case did not offer the slightest impediment.

At the present day there can be no excuse for building such dams. Dam building has passed beyond the experimental stage, and enough dams have gone out, and enough stood, to afford abundant standards for all ordinary classes. In view of the fact that dams and reservoirs are bursting all over the country every time it rains rather harder than usual, owing to flagrant violations of the elementary principles of sound hydraulic construction, is it not time that such structures should be subject to the inspection and approval of a duly appointed board, just as city buildings are?

E. Sherman Gould.

Yonkers, N. Y., July 23, 1897.

The Cazin Impulse Water Wheel.

Sir: I have never entertained a doubt but that the company who are exploiting Mr. Cazin's ideas thought they had a good thing, and that Mr. Cazin would support them in that belief, and further, that their opinions would not be altered by anything emanating from an outsider. Therefore I addressed myself to the editor of Engineering News and its readers, knowing that they were amenable to reason, and very properly referred them for proof of what I said to their only known source of information on the subject, i. e., the editorial cited. But I may say that a careful study of the American

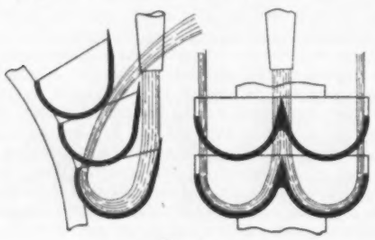


Fig. 1.

Impulse Wheel Co.'s pamphlet would have given little further information.

I certainly had not the intention then, nor have I now, to engage in combat with a "windmill," as Mr. Cazin so appropriately calls himself; but I feel it my duty to reply to such portions of his letter as were intended as an answer to my criticisms, though I do not believe that in the mind of any intelligent person the strength of my position has been impaired by what he has said.

Mr. Cazin says that the water, after its passage over the surfaces of the bucket, falls clear of the wheel, owing to the action of gravity, there being nothing beneath to interfere with it. Now this is all very well, provided there is time enough for gravity to act, but unfortunately the next bucket comes into position before that water has had time to fall an appreciable distance, therefore it is struck by the back of the bucket. The action is precisely the same as striking a ball with a bat, the ball having been tossed a few feet into the air for the purpose and struck shortly after reaching its highest point.

A simple calculation may show this better. Assume a wheel of 96 ins. circumference with 48 buckets (I take the proportions approximately from a drawing of a Cazin wheel), running under a head of 100 ft. The velocity of the rim is $\sqrt{\frac{2\,gh}{2}} = 40$ ft. per second. Now the distance between buckets is $\frac{96}{48} = 2$ ins. (really less), which distance is traversed by a bucket in $\frac{2}{40 \times 12} = .004$ seconds (approximately). Then, in order to be out of the way of the approaching bucket, the inert mass of discharged water must fall clear of the wheel in .004 seconds. In this time it will fall $\frac{g\,t^2}{2} = .00025$ ft. $= \frac{3}{1{,}000}$ in., instead of the two or three inches necessary. Mr. Cazin will surely not persist in the ridiculous claim of a free discharge in this way; especially when attention is called to the fact that his attempted explanation applies only to buckets in action at the lower part of the wheel, and not at all to buckets supplied by the upper nozzles shown in his drawings.

But a graphical illustration is more striking where the water is represented as passing over the stationary buckets instead of the buckets passing over the water.

From Fig. 1 it is evident that the drop due to the action of gravity (though shown greatly exaggerated) in the space between the buckets is wholly inadequate for clearance, and that the only solution is as indicated in Fig. 2; in other words, by the use of a clearance angle, in this case in an axial direction, as is done by all experienced designers.

As to the free discharge of the Cazin wheel being demonstrated by tests, as Mr. Cazin states, I will simply ask such persons as possess a copy of the "Perfect American Hurdy Gurdy" if they do not agree with me in thinking

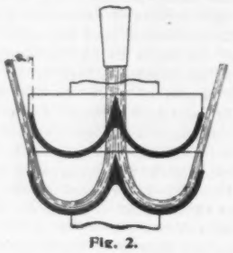


Fig. 2.

that the wheel shown in the photographic frontispiece (which I presume was used for tests) was constructed with a clearance angle; in other words, that the wheel tested was not a Cazin wheel, but substantially a Pelton.

Mr. Cazin intimates that I understated the loss due to discharge angle. So far as diversion of the stream is concerned, the efficiency is $\frac{1 - \cos \phi}{2}$, where ϕ is the average angle through which the stream is turned, and equals 180°, the discharge angle. Assuming an ordinary value of discharge angle, 10°, we have the efficiency $= \frac{1 - \cos 170°}{2} = 99\frac{1}{4}\%$. That is, the loss due to this source is under 1%, as I stated.

My statement that complete and constant "inversion" of the stream (which he claimed) is impossible, Mr. Cazin apparently sees the hopelessness of disputing.

When a problem presents itself, it is customary for an engineer to apply himself to its solution rather than to search for a result obtained by somebody else, which he may follow. So it is that I can quote no authority for the proper number of buckets on a tangential wheel other than common sense. Obviously the minimum number of buckets is determined by the condition that when the wheel is running at the proper speed, no water shall pass through it without acting on a bucket. It is equally obvious that the number of buckets should be as small as possible to diminish fractional losses. The number of buckets must then vary with the ratio of diameter of stream to diameter of wheel, and in a particular type of wheel vary with nothing else.

Mr. Cazin's defense of the use of a large number of buckets amounts to this; "if the friction is zero, three times the friction is zero; the entrance disturbance is also zero because the entering edge of the Cazin bucket is so very

Fig. 3.

sharp." I need hardly say that the friction is far from zero; and, after he has had a few months' experience, I need hardly tell even Mr. Cazin that the entering edge rapidly becomes blunt under the action of the water, which always contains more or less solid matter. In some localities the buckets are entirely worn away within two months, of whatever material they be made. Fine entrance is a delusion.

Mr. Cazin is certainly not alone, as he would lead us to believe, in making the outer entering face of the bucket tangent to the stream, for in this he has but followed every manufacturer of tangential wheels. Mr. Cazin has made the mistake of assuming that the drawing of a Pelton wheel which he referred to shows the form of bucket face where the stream strikes it. Here he was in error, as a sectional view would have shown the face to be tangent to the stream at entrance. My meaning can be understood more readily by reference to Fig. 3, which represents a Dodd bucket, viewed in the direction of the entering stream.

The common form of Pelton bucket is shown in Fig. 4, though under special conditions, as in the cited drawing, the front and back faces are not flat.

The reliability of the tests referred to by the Pelton Water Wheel Co., I have never heard disputed by any one save Mr. Cazin; however, the test on which I based my statement of a commercial efficiency of 93% has not, I believe, been questioned even by him; it is the test of the 18 ft. Pelton wheel at the North Star Mine, made by Mr. A. De Wint Foote and Mr. E. A. Rix, and reported by Mr. Foote in a paper read before the Am. Soc. C. E. a year ago.

The atrocious crime of being a "young man," of which the honorable gentleman accuses me, I shall attempt neither to palliate nor to deny. But in view of Mr. Cazin's statement of the satisfaction with which he views his achievements, I cannot but withdraw my remark that he has been wasting his time—his own satisfaction having undoubtedly been his aim. I see no reason, however, for modifying my belief that the promoters of his schemes are wasting their money. Very truly yours,

Dorville Libby, Jr.

San Francisco, Cal., July 6, 1897.

(According to our usual custom, we submitted this letter to Mr. Cazin and give his answer below. —Ed.)

Sir: The contents of Mr. Libby's letter call for but a few words on my part. Had Mr. Libby confined himself to the technical issue under consideration, I should with pleasure continue the discussion, but, as it is customary

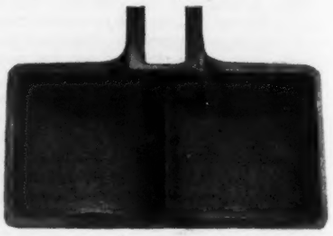


Fig. 4.

with those more devoted to scientific and technical progress than attached to specific manufacturers' interests, I cease discussion when the adversary has uncovered his purpose in the latter direction. But were I to continue the discussion, it would be my duty to draw attention to the fact, that the angle of diversion is in no wise a characteristic distinction between the Pelton bucket and the Cazin bucket, and that it is only deceptively made the main issue If anything could possibly be gained by diverting the discharge water at any angle, the American Impulse Wheel Co. would not be prevented from using such an angle of diversion by fear of infringing the patents covering the Pelton wheel, because their patents leave it absolutely free to them to give any shape to the buckets of their wheels, as long as they adhere to the parallelogram form of the front edges of their buckets, to the knife extending beyond them, and to the semi-circular form of the completing apron. The question of a diverting angle, moveover, relates to one instantaneous position of the Pelton bucket only; the main question being the total absence in the Pelton bucket of proper curvatures in the trail of the jet through the bucket cavity.

It only remains opportune to contradict some of the statements made by Mr. Libby. The wheel shown in the photographic frontispiece was not constructed with a clearance angle. It was and is a Cazin wheel, with a cavity that has four triangular sides meeting, with their apex in the deepest point of the cavity. Each pair of opposite sides is curved to form, at their central section through the deepest cavity-point, a segment of a true circle. This construction, with the accessories of lip and apron, leads the jet over a tangent and around a complete semi-circle while it is in contact with the vane, and discharges the exhausted water between the intervals of the vanes without any detrimental effect, Mr. Libby, Jr., notwithstanding, by means of a centrifugal impetus, added to that of gravity, sufficient to clear the wheel without lessening its efficiency. The course of the escaping water is left free by the outer half of each bucket projecting laterally beyond the wheel-crown. The number of buckets and the arrangement of the buckets in pairs, or in a right and left hand series of single buckets, are matters of free selection and are determined by the

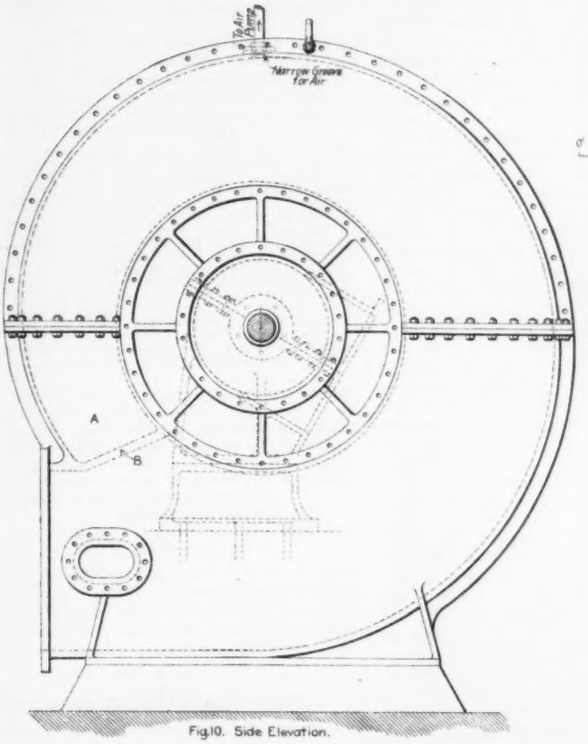


Fig.10. Side Elevation.

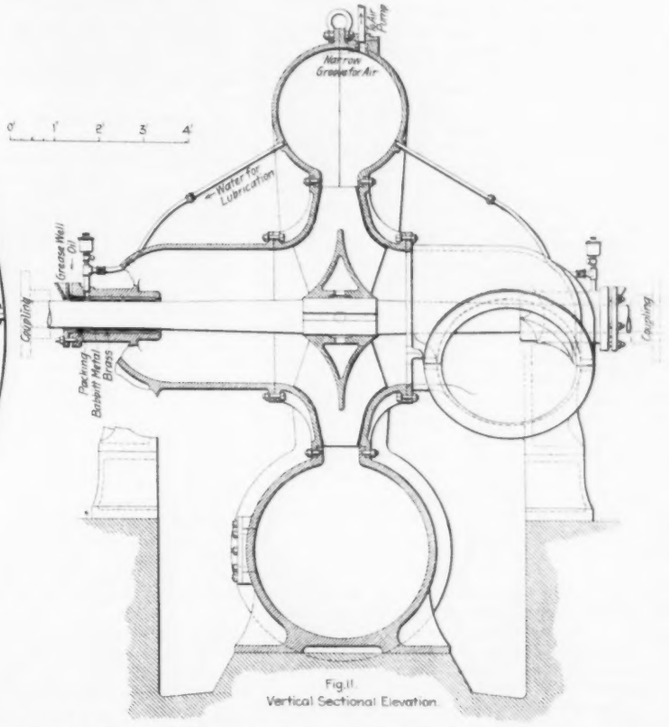


Fig.11. Vertical Sectional Elevation.

FIGS. 10 AND 11. DRAINAGE PUMP FOR NEW ORLEANS, LA., CAPACITY 19,000 CU. FT. PER MINUTE. THE NEW YORK DREDGING CO., CONTRACTORS.

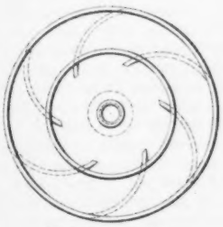


Fig.3. Elevation of Vanes.

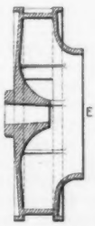
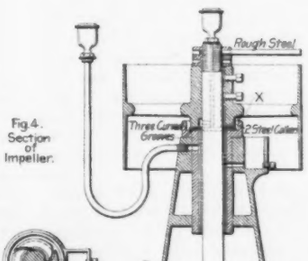
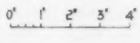


Fig.4. Section of Impeller.



Plan at X.



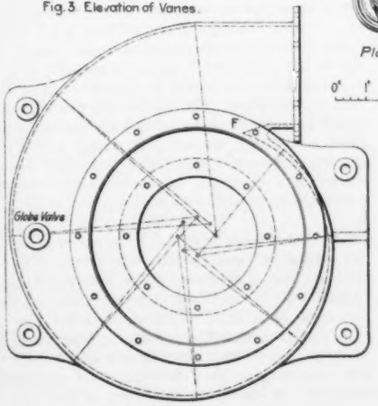


Fig.2. Plan.

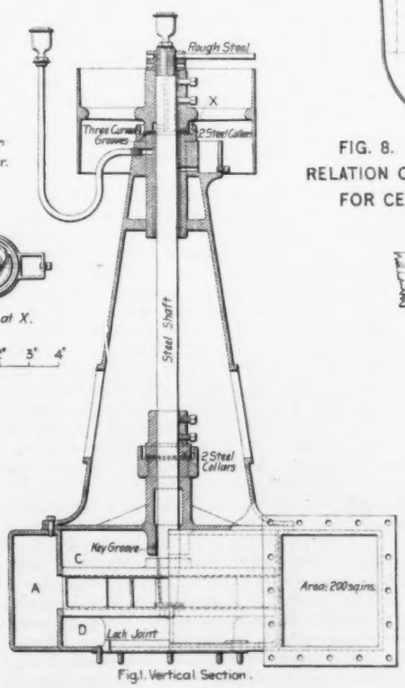


Fig.1. Vertical Section.

FIGS. 1 TO 4. VERTICAL CENTRIFUGAL DRAINAGE PUMP FOR SACRAMENTO, CAL., 1883.

FIG. 8. DIAGRAM SHOWING RELATION OF BLADES AND CASING FOR CENTRIFUGAL ACTION.

FIG. 9. DIAGRAM SHOWING RELATION OF BLADES AND CASING FOR IMPULSE ACTION.

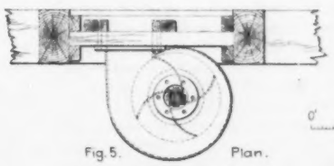


Fig.5. Plan.

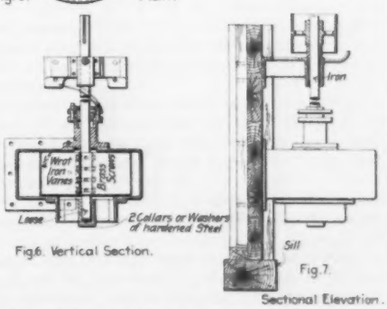


Fig.6. Vertical Section.

Fig.7. Sectional Elevation.

FIGS. 5 TO 7. BULKHEAD DRAINAGE PUMP FOR ISLETON DISTRICT, SACRAMENTO VALLEY, 1885.

THE DESIGN OF CENTRIFUGAL PUMPS.

(By J. Richards, San Francisco, Cal.)

CHAS. HART & SONS, LITH., 26 VESEY ST., N. Y.

conditions of any specific case. Neither in the one case nor in the other has this company limited itself to any exclusive position. Hence it has no intention of defending any. Neither does this company "make the outer entering face of the bucket tangent to the stream," leaving such an arrangement exclusively to those whose interests are defended by Mr. Libby, Jr.

The suggestion on the part of your correspondent of July 15, "that a practical, competitive test of the two wheels be made," had the approval of the American Impulse Wheel Co. long before your correspondent made it. In its pamphlet published four months ago, the manufacturers of the Cazin wheel state as follows:

We have in our wheel all that is meritorious in the Pelton, and we further have in our wheel much that is meritorious that the Pelton has not, namely, the feature of complete and absolute inversion of jets in all positions of the buckets,—the indispensable condition of highest efficiency. * * * We guarantee our wheels to produce more power than any other water wheel in the market. * * * We know of no practical way of settling the question of superiority regardless of all scientific or theoretical causes therefor but to challenge our competitors to a comparative test by competent, impartial hydraulicians on the basis of previously accepted rules, valid for all competing wheels. We have solved the question to our own satisfaction and we are ready to solve it to the satisfaction of the entire engineering fraternity. Until this be done we rely on the theoretical knowledge of all educated engineers as the means for establishing the practical superiority of the Cazin wheel.

This general challenge has never been retracted, and stands to-day as it stood on the day of the issue of our patents. As Mr. Libby evidently represents the Pelton Water Wheel Co. as their press-agent, he may be authorized to accept the challenge of the American Impulse Wheel Co. as the best means for deciding in a practical way the question of more perfect construction.

American Impulse Wheel Co.,
F. M. F. Cazin, Consulting Engineer.

120 Liberty St., New York, July 17, 1897.

(As this discussion has now reached a point where little is to be gained by continuing it along the present lines, it will be closed with the publication of these two letters, as far as our correspondence columns are concerned.—Ed.)

THE DESIGN OF CENTRIFUGAL PUMPS.

By J. Richards, San Francisco, Cal.

(With one-page engraving.)

Before proceeding to speak of centrifugal pumping in a technical way, it may be noticed that their distinguishing features are: (1) Continuous action of flow, consequently constant and uniform resistance to the driving power, and the absence of shocks and strains such as are set up in all hydraulic apparatus of intermittent action. (2) The velocity of the water is increased as it passes through the pump to at least double that common in conducting pipes, and in practice is about five times as great as is common in intermittent or piston pumps. (3) The weight and cost of the pumps is approximately as the velocity of flow, or in comparison to piston pumps about as one to five for a given amount of water when the volume exceeds 5 to 10 cu. ft. per second. (4) There being no metallic or other contact in the running elements and no valves, the maintenance of centrifugal pumps is a merely nominal expense, commonly not 1% a year in pumping clear water.

These conditions render the subject one of much importance, especially as machinery for the movement of large volumes of water is every year increasing all over the world. The evolution of centrifugal pumping has gone on with normal regularity for fifty years past and as rapidly as could have been expected when the circumstances are considered; certainly faster than fair inference will permit if we compare centrifugal pumps with other machines or implements.

During the same period great changes have been made in the positive or piston class of pumps, the most notable within a few years past, yet a piston pump is in comparison a machine of very simple nature and quite uniform for nearly all uses except as to strength, or adaptation to pressure.

Had centrifugal pumps, like most other hydraulic apparatus, been amenable to computation for forces and results, problems of design and adaptation would long ago have been settled and the practice would have become quite uniform; but this is not the case, for several reasons. In the first place the head, or resistance, is a direct factor in a pump's design, demanding adaptation for even small variations of head, and secondly, when the various quantities and dimensions are computed, these must give way to various conditions of operating that take precedence, so that when adaptation to head and to the circumstances of use are complied with, the designer will find himself far outside of the original computed quantities.

This is awkward and annoying and also is expensive, and we may add is disputed; but the facts of practice go to show that successful centrifugal pumping, especially in the case of large pumps where the work is measured accurately, is to a great extent a matter of experience and empirical rules.

As such assumption is at this day a kind of "heresy," some explanation should be made of what is meant, first, however, citing an example of the pitfalls that beset the designer.

An able engineer who recently investigated this subject of centrifugal pumping discovered and demonstrated theoretically that to attain the best efficiency with pumps of this kind, the water should leave the impeller at the full velocity of the latter, and then expend its full kinetic energy in promoting flow of the discharge. In other words, the water in the casing around the impeller should partake of the impeller's velocity and then be gradually reduced to the discharge flow.

This theory was correct, no doubt, under certain assumed conditions; for example, if the velocity is a function of the head, then a pump made as suggested could operate at but one head or pressure, and within limits too narrow to permit profitable manufacture for general purposes. Again, if the velocity of the water around the impeller is fixed, or a condition of constructive arrangement, then the pump would be a "positive one" and removed from the centrifugal type altogether, both as to capacity and mode of operating. An example of pumps operating in this manner, constructed in 1885, will be given later.

This fact points to or rather indicates one of the fundamental conditions that must be provided for in centrifugal pumping, viz.: the variations of velocity between the impeller and the discharge duct that surrounds it.

Another computed condition of centrifugal pumping is that the path of the water should be a volute from the entrance to the periphery of the impeller, moving through 360°, and then passing to the discharge duct. This seems sound as a theory, and is so, no doubt, in so far as the dynamic conditions are concerned; but if followed out, the rotative speed of an impeller will become such as to produce undue agitation and heat in the water, besides being destructive to packing glands and spindle bearings. Numerous experiments have proved the futility of this method in practice, and it is commonly abandoned, by makers who try it, after a few pumps have been made.

Another law of fluid-moving apparatus that has to be violated in the construction of centrifugal pumps is that of uniform velocity. However one may desire to apply a feature so obviously correct, he will find his path obstructed in centrifugal pump designs. For example, if a pump is of 20 ins. bore or discharge, the impeller for various reasons should be at least twice this much, or 40 ins. in diameter and 125.64 ins. in circumference. The area of the water ways, if uniform throughout, will be 314.16 sq. ins., which, if divided by the circumference of the impeller, gives a width of 2.5 ins. for the pump throat, which might answer if a pump were to be employed in raising or forcing pure water, but for drainage purposes such a construction would not be admissible, because obstruction of one kind and another would lodge in the throat, while in dredging or in pumping sewage such dimensions would be absurd.

The engineer has, therefore, no choice. He must ignore the uniformity of flow and diminish velocity at least a half, sometimes to a fifth of what true theory demands. These are some but not all of the features in which centrifugal pumps cannot conform to computed dimensions. There might also be mentioned the commercial necessity of applying one design and one set of patterns to different heads, of course, within reasonable limits.

Remarks thus far have been confined to centrifugal pumps operating at low pressure against heads up to 30 ft. or so; but when the head is increased to twice or three times this height, there arise various problems, constructive and other, that lie outside the province of this article and demand separate consideration. Some examples of practice in high pressure pumps will be given later, but their use is at the present time too limited to have much interest to the engineering profession in general.

Drainage Pump, Sacramento, Cal.

Figs. 1, 2, 3 and 4 of the drawings show a vertical pump constructed in 1883 for the corporation of the City of Sacramento, Cal., which forms an interesting link in the history of centrifugal pumping on the Pacific Coast.

Its purpose was to raise the surface drainage of the city about 9 ft., at the rate of 7,500 gallons per minute (16.6 cu. ft. per second).

About three years later there occurred some difficulty over the outfall, which was changed from a slough to the Sacramento River, increasing the head to 17 ft., at which head the pump went on for several years performing successfully, but of course at low efficiency, when a new pump of more complete design and adaptation was substituted.

Tenders for the first plant were publicly advertised for by the Engineer and Board of Trustees in 1883, and the bids received indicated that at that time the "art" was in a very backward state in this country, where centrifugal pumping may be said to have had its origin and first practical application, about 1830.* The estimates of capacity in some cases reached 80 gallons per minute for each square inch of the discharge area, or a velocity of 24 ft. per second. The power, efficiency, etc., were chaotic, when compared to practice in the Low Countries of Europe and in various dock plants in use at the time.

The pump shown in the four figures named is an interesting study. Referring to the section, Fig. 1, it was assumed that inductive action through the passage A, into the volute discharge way, would so reduce the pressure in the chambers C and D, and especially in C, that there would be no vertical thrust on the impeller and spindle.

This proved fallacious in some degree which was never ascertained. There was a heavy thrust downward which, added to the weight of the rotative parts, imposed a severe duty on the double set of thrust bearings provided. Copious lubrication and the rapid convection of heat from the lower thrust bearing, due to its proximity to the water, enabled the bearings to be maintained.

The vanes, as shown in Fig. 3, were curved to produce as far as possible "radial" flow from the impeller, but the inductive action through the inner wall of the volute case, if it existed at all, was weak and the result was a pressure in the chambers C and D nearly equal to the head, with a consequent down thrust equal to the difference in area between the top and bottom of the impeller, or as the area of the inlet way at E, Fig. 4.

This thrust, which was the principal impediment to deal with in the operation of this pump, could easily have been avoided and even reversed so as to balance the weight of the running parts, by putting vanes on the top of the impeller to cause a revolution of the water contained in the chamber C, but this was not known at the time, or for several years later, and is even now a problem of some intricacy.

"The Bulletin No. 2" of the University of California, issued in 1887, five years later, is the first literature that can be referred to which places this subject of lateral thrust on impellers in a light to be understood.

The experiments were made under the direction of Prof. F. G. Hesse, then and now Chief of the Mechanical Engineering Section, and were conducted with carefully made apparatus illustrated in the Bulletin referred to.

This thrust was not, however, the only objectional feature developed by the Sacramento pump.

It will be noticed in the plan, Fig. 2, that the vanes of the impeller come near to the throat, or cut-off, at F. The drawing shows half an inch or so of clearance, but in fact the impeller came almost in contact. The pump was set on timber, and on being started there were set up a series of rythmic pulsations of "high frequency" which might be compared to the sound and action of a wood-planing machine. This was a mystery. It

* Richard's "Centrifugal Pumping," 1893, p. 33 et seq.

was an abnormal condition, evidently, but did not seem to impair the pump's efficiency, and we had to wait for five years more for an explanation.

This is candid confession, certainly, and if any one can find in the literature of centrifugal pumping previous to that time any explanation of the matter, it will lay the designer open to a charge of incompetency, but this he imagines cannot be done. The same feature and fault is present in many pumps designed at the present day, and supposed to be high-class machines; but the fault is not so obvious as in this case where the conditions of "resonance" were especially favorable.

As before remarked, the impeller, speed of revolution and other circumstances produced in this pump a nearly radial flow from the impeller, and this flow was obstructed at F at each revolution, and between each of the vanes, the pulsations corresponding to the speed, about 200 revolutions per minute, multiplied by the number of vanes, which gave about twenty pulsations per second. This synchronized, no doubt, with the vibrations of the timber supports. It was a curious phenomenon, and, as has been said, it brought about the step forward in the evolution of centrifugal pump design.

Bulkhead Pump, Sacramento Valley, Cal.

The pump shown in Figs. 5, 6 and 7 was of a hybrid nature in so far as the action of the impeller was concerned, as it operated both by centrifugal force and by tangential energy or "impulse," but the proportions of the two were unknown. It is open to some of the objections that apply to the pump first illustrated, but not all, and is, perhaps, the cheapest form of water raising apparatus that can be devised.

It was one of a pair constructed about 1885 for the Isleton District, on the Sacramento River, and, aside from objections to the driving power and gearing, which were faulty, performed very well at a fair efficiency. It was, so far as known, the first attempt to eliminate atmospheric action in drainage pumps on the Pacific Coast, and this, with the timber framing and other features discernible in the drawing, will indicate the extreme cheapness of the plant.

It must also be explained that the design was prepared some years before the pumps were made, and some change was made that can be explained by referring to Fig. 5.

It will be observed that the vanes sweep over one-half of the discharge way. This was increased to three-quarters and the volute casing was contracted accordingly; the object being to secure impulsive effect or "mechanical push" of the water which at low heads is not only practicable but more efficient than to depend on centrifugal action with some aid from tangential energy.

Other pumps were made of analogous design, but of more permanent construction, in which the vanes filled or swept the whole interior of the casing, operating mainly, or almost wholly, by "push" or by "impulse," as it was called for want of a better name.

The distinction between centrifugal force and impulsive action in pumps is a matter of great importance in their design, and is relatively a condition arising out of the head or resistance, because tangential effect, a potent force at low heads, almost disappears at high heads, or when the pressure required demands a speed of rotation far in excess of the discharge flow.

This difference of method is illustrated in Figs. 8 and 9, being diagrams taken from uncompleted plans, for heads of 3 ft. and 18 ft. respectively, Fig. 8 being a centrifugal pump, and Fig. 9 an impulse pump designed to move at low velocity and with but little centrifugal effect when compared to the one shown in Fig. 8.

The off flow in both cases is computed at a velocity of 10 ft. per second, and as the relative speed of the two impellers would be in impulsive and centrifugal working approximately as 1.75 to 6, the difference in these quantities represent the "slip" of the vanes with respect to the discharge flow. In Fig. 9 the theoretical velocity of rotation would be about 20 ft. per second, or twice that of the discharge flow of the pump when operating by centrifugal force, but this is not the result in practice, nor is it expedient if it were possible. The speed of the impeller should correspond nearly to the velocity of the flow, and by "natural selection" will assume that speed under low head.

In Fig. 8, however, the circumstances are all changed. The velocity of the impeller will have to be from 50 to 60 ft. per second, depending somewhat in the shape of the vanes. The slip becomes 40 to 50 ft. per second, with corresponding decrease of effect from tangential energy not in proportion to slip or over-running, however, but in some unknown degree which experiments have failed to determine.

It would be of infinite benefit if these working conditions and a good many more to be referred to in future could be resolved in mathematical form. They will be some day, no doubt, and formulated from experiments, as are nearly all data of the kind, but as before remarked Centrifugal pumping, less than any other process, is indebted to computed results or to calculations based on theory.

Impelling Screws.

In connection with what has been called impulsive acting pumps, this would be a proper place to discuss the action of screws employed as pumps for raising and impelling water.

The history of this method of pumping points to limitations of head and also of efficiency. It was an early suggestion, arising out of the use of the screw propeller for vessels and has for fifty

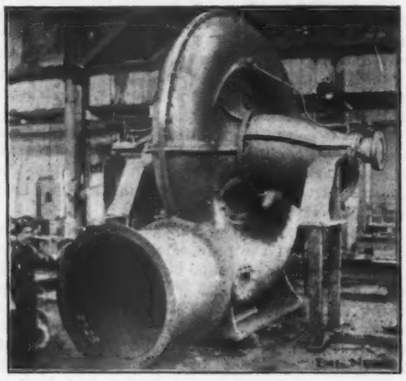


Fig. 11a.—Perspective View of New Orleans Drainage Pump.

years past been adopted at intervals, to be abandoned again, except in a few cases where the volume is large and the resistance or head inconsiderable.

In 1895, Mr. Charles Brown, of Basle, Switzerland, an engineer of eminence, carefully considered the application of this propeller method for raising the flood water at New Orleans, La., employing what may be called the "Jonval system," that is, the method of the Jonval water-wheel reversed, the water being disposed in an annulus with impelling and baffling vanes developed to meet the hydraulic conditions and produce a straight line flow. This scheme embodied the ultimate efficiency attainable and it is to be regretted that the computations are not available for production here. They were not encouraging, however, although lending themselves in a remarkable degree to certain physical conditions of erection and maintenance under a low and invariable head.

In California a good many pumps have been made fitted with propellers at distances of two to four feet apart, or in the line of the barrels, which were in some cases made serpentine in form to prevent rotation of the water. This was a modification of and was inferior to the propeller pumps of Thomas Shaw, of Philadelphia, invented and experimented with about 25 years ago.

The conditions of operation in pumps of this kind are such as to consume a great share of the power in agitation, as the matter was graphically expressed by Mr. Jas. D. Maxwell, of Cincinnati, Ohio, a well-known hydraulic engineer, who, on examining one of the Shaw propeller pumps, remarked: "It requires power enough to raise water quietly, without churning it up in that manner."

Efficiency and agitation never go together, and it is a safe rule that efficiency of any water impelling machine is inversely as the agitation set up within or by it. This rule is applicable alike to pumps, water wheels, propellers, and indeed to all fluid raising apparatus. It was on this ground mainly that Professor Huet, of Amsterdam, Holland, contended against centrifugal pumping in his essays on the subject.

He, in common with many others, in considering centrifugal pumping assumes that there is agitation in centrifugal pumps by reason of the high velocity of the impellers—a fair inference, no doubt, but the fact is that in no other apparatus, unless it be a lifting bucket, is water moved with a greater degree of "solidity" than by centrifugal pumps. This is proved by the small amount of air given off in the discharge ways. Even in pumping surface drainage, where the water is charged with the gases of decaying vegetation, and in deep wells which give off carbonic acid gas, as in some of the irrigation districts on the Pacific Coast, centrifugal pumps always work "solid" unless there are air pockets. A reason for this is the rapid flow through the pump which carries out gas or air by entrainment.

Drainage Pump for New Orleans, 150 cu. ft. per second.

Figs. 10 and 11, and Fig. 11a are taken from one of a pair of drainage pumps recently erected at New Orleans, La., by the New York Dredging Co.

There are several features of interest in the design. One is that the free discharge chamber beginning at A, with a section equal to one-fifth of the discharge way, is in excess of common practice for large pumps.

The double inlet or suction pipes were adopted to meet conditions imposed by the driving power and not from choice. The impeller, in order to attain a speed determined by the engines, was reduced to a diameter that would not admit of a single inlet at one side which otherwise would have been desirable for the head, which was 12 to 14 ft.

The spindle bearings, it will be seen, are made integral with the side pipes and inside the glands, the purpose being to shorten the distance between the bearings, which is here reduced to two diameters of the discharge pipe.

The guaranteed efficiency of these pumps is 65% of the applied horse-power, in water raised, which guarantee will, no doubt, be attained.

The cut-off plate B will no doubt form a subject of criticism, in view of some recent computations and writings respecting what is known as the Chabaver method of providing for a gradual reduction of the rotary velocity of the water, which method assumes certain premises that have not been proved in practice. In respect to the theory it may be pointed out that within two years past there has been presented, with due support of formulas, the statement that a pump should have a wide annular space around the impeller; also that there should be no baffling vane or throat plate at all.

The cut-off plate, B, that formed so conspicuous an element in the first "Parsons experiments," has long been a matter of contention. It is commonly set as nearly as possible parallel to the angle of discharge from the impeller at some assumed velocity or head, and when in that plane offers no retardation of the flow. Its function is, in fact, a problem of liquid friction.

With this baffling plate the line of division between the body of water moving with the impeller and the body of water around the impeller is a circular or rather a cylindrical surface touching the inner edge of the plate or at the periphery of the impeller, the frictional water surfaces being confined to that circle; but if this plate or diaphragm is removed, then the parting or line of change in velocity is not a circle, but becomes a volute with extended surface and lower velocity.

It is safe to assume that very little is known of the dynamic conditions set up in the two cases. The Parsons experiments prove nothing, because the pump was driven at the same velocity when tried with and without the cut-off wedge or throat piece, and every one experienced in this matter knows that without the throat piece or cut-off the velocity of the impeller must be considerably increased.

The writer has experimented a good deal in this matter, and while not disputing the grounds of the Chabaver or "whirlpool" theory, has found the best results with pumps provided with a cut-off or baffling plate such as is shown at B, and he assumes that while the rotative energy of the water is to a considerable extent conserved by a whirlpool chamber, agitation and water friction causes a corresponding loss of general effect.

Compensating losses are the hidden rocks in the path of theories respecting centrifugal pumping. No doubt most of the computed methods are correct in so far as the particular forces treated and included, but it must be remembered that computations are of necessity based upon constant conditions of operating as to speed and head, and also on the behavior of the water in the pump, none of which form stable premises. What is gained in one way is lost in another, and the safest guide is observed results.

(To be Continued.)

A TROLLEY-CARRIAGE TO RUN ON COMMON ROADS.

By Gilbert P. Coleman.

A motor carriage has been invented, and is now in operation at Greenwich, Conn., which will run without interruption for an indefinite time, and is not dependent on the caprice of a storage battery. The contrivance consists substantially of a trolley car, or more properly, carriage, which runs on the highway instead of on rails, and is termed by its inventor an "electric trolley stage." But although in its general design it is constructed on the plan of the familiar trolley car system, there are several respects in which it is materially different.

The motive force is supplied from the power house by means of a current of electricity conveyed along the side of the road by two copper wires supported by poles situated about 30 yards apart. On account of the absence of rails it is necessary to employ two wires to make the circuit complete. The current passes out through one and returns through the other. Each carriage is provided with a double flexible metallic cable, corresponding to the trolley pole of the street car system. By means of this trolley connection the current is conveyed to the motor under the carriage, and from thence passes back to the return wire. It will be seen that this arrangement is very similar to the wiring of incandescent lamps in parallel, each carriage in the one,like each lamp in the other, abstracting from the main circuit an amount of power sufficient for its needs. In this way the loss of power by electrolysis, which is a considerable factor in the ordinary trolley system, is avoided.

Experiments with the electric trolley stage have been going on for the past six months on what is known as the Steamboat Road at Greenwich, under the supervision of the inventor, Mr. Henry Van Hoevenbergh, and several persons interested in the Greenwich Electric Lighting Co. The "stage" is in reality a storage battery carriage, obtained by Mr. Hoevenbergh for the purpose of the experiments on account of its pneumatic tires. It is a much more cumbersome affair than is needed, as the large space in the rear, formerly used for the storage batteries, can, under the trolley arrangement, either be eliminated, or devoted to seats. The size and shape of the vehicle to be finally used in this system will, of course, depend on the class of traffic it is to carry.

The motor that drives the wheels is situated under the forward part of the carriage. The steering apparatus is operated by means of a lever, also from the forward part of the vehicle, and is made to connect with the rear wheels. The power is applied from the motor to the forward wheels, so that, as regards the method of applying power and of steering, the trolley carriage is just the reverse of the bicycle.

By means of a very ingenious contrivance, the carriage may be stopped or started by a single motion of the foot. The brake is of the ordinary sort used on wagons and trucks and is controlled by the foot. A horizontal bar is attached to the brake rod, and this engages a cog wheel in such a manner that when the brake is released the cog wheel is turned and the motor is set in operation. On the other hand, when the brake is applied the power is shut off.

Connection between the circuit wire and the motor is made by means of a double wire. This is wound around a cylinder located in the carriage and worked by a spring. When it is desired to pass from one side of the street to the other, the two trolley wires wind or unwind automatically on the cylinder, the spring serving to keep them always taut.

The circuit wires are hung side by side about 8 ins. apart, and are suspended by means of metal arms from a third wire. A cross section of the three wires would indicate the vertices of an isosceles triangle, the upper or suspending wire forming the apex. The device by which the trolley is conducted along the circuit wire is very ingenious, and it is this which, perhaps, constitutes the most valuable feature of the invention. The problem which Mr. Van Hoevenbergh had to solve was to devise some means whereby two trolley vehicles might pass each other readily, and whereby each might turn around and pass from one side of the road to the other. As finally designed, the contact device consists of a set of rollers attached to either of the main circuit wires, and so guarded that it will not fall off, or "run away" when the vehicle is descending a hill. For vehicles which are passing in one direction, say south, for instance, the trolley rollers are attached to the inner wire, or the one next the sidewalk, while vehicles passing to the north feed from the outside wire. With a little care the motormen of the vehicles passing in opposite directions may manipulate their trolley wires so as to avoid any possibility of confusion. It is this facility of movement and control which will no doubt prove a very valuable feature of the electric stage. The arrangement of the rollers and connecting wires is such as to permit of the stage being run in either direction at will, and of being turned around, and of crossing from one side of the road to the other, as if it were drawn by horses. On a fairly level road the motion is as easy, owing to the friction-saving pneumatic tires, as that of a trolley car on rails, and unlike the trolley car, the trolley stage is not confined to the strict limit of direction and space to which the former is subject.

In the trials thus far made the line extends along a distance of about a quarter of a mile, the road being fairly smooth and slightly rolling. At one point the conducting wires pass from one side of the road to the other, but this circumstance has no effect whatever on the running of the vehicle, on account of the flexible arrangement of the connecting wires. As at present constituted, the stage can be easily made to accomplish the distance of a quarter of a mile in 45 seconds, which is fairly good time when it is considered that the sole object of the experiment has been to attain facility of operation rather than speed. One great advantage of the system is that it is almost noiseless, the only indication of its approach being a slight whirring sound on the wire. For this reason, it has very little effect on passing horses. It has been demonstrated that the stage will run quite readily over a muddy road, and also over one covered with ice or snow. Another advantage which it possesses over the ordinary trolley system lies in the fact that the wires are situated at the side of the road instead of overhead.

The operation of the trial line at Greenwich has been so successful that it will soon be extended so as to run from the railroad station to the end of Steamboat Road, a distance of a little over a mile. In case the experiment over this increased distance should also prove successful, the promoters intend to build a permanent line from the station up to the center of the town, a distance of a mile and a half, and this line will be operated regularly for the convenience of the public. Many attempts have been made to introduce a regular trolley line in Greenwich over this route, but they have always failed, for the reason that the citizens are proud of the beautiful appearance of their village, and object seriously to the disfiguring presence of trolley wires and rails. Under the proposed arrangement, however, these objectionable features will be avoided, and it is expected that there will be no opposition to the plan of establishing a permanent "trolley stage" line, which, by the way, will be the first of the kind in the world.

ELECTRIC TROLLEY CARRIAGE AT GREENWICH, CONN.
Henry Van Hoevenbergh, Inventor.

HYDRAULIC ENGINEERING IN CENTRAL ASIA.

In the "Memoirs" of the Society of Civil Engineers of France, M. Poklewski-Koziell makes note of some novel methods used in Central Asia in carrying out hydraulic work. The first note relates to the regulation of the River Cache, at a point where a bend threatened to undermine the bank of a canal and thus deprive the town of Kuldja of water. At a shallow part of the river, above the threatened point, the author planted a series of tripods made of poplar logs, 6 to 8 ins. diameter and 10 to 13 ft. long, These tripods overlapped so as to form an open lattice work, and against them were placed long fascines loaded with stone. The interstices were filled with grass and straw which caught the silt. This dam was about 984 ft. long, and it was built in six hours; the collecting of the material and the digging of a new channel consumed three days, with the aid of 6,000 men and several hundred two-wheeled carts.

In rebuilding the old dam at Sultan-Bent the river was first widened to 180 ft. to facilitate the passage of water during construction. This dam was founded on mattresses made of crossed fagots, the mats being each 32 ft. square and 4 ft. 10 ins. thick. The upper side was divided by interlacing twigs into pockets 2½ ft. square, to receive the brick to be used in sinking the mats. Each mat weighed 33,000 lbs. and the brick add

40,000 lbs. more. These mats formed a floor, 197 ft. long and 66 ft. wide; and on this floor were placed heavy fascines, 16 ft. 5 ins. long by 3 ft. 6 ins. diameter, and weighing about 5,300 lbs. each. These fascines were swung into position from an upstream mooring, and sunk across the stream in a double line; the width being increased as soon as they extended clear across the stream. The first rows of fascines sunk in the sand and others were added until the dam gradually rose above the bed of the stream. As soon as the dam was formed, bundles of hay, weighted down with bricks, were packed against the fascines and the river bottom above was stirred up so as to deposit silt in the interstices of the dam and thus tighten it. In this manner Mr. Poklewski-Koziell raised the water level 32 ft. 10 ins. and formed a reservoir extending upstream 26 miles. Progress was slow to allow the work to settle thoroughly and the silt to pack in the dam and form a deposit upstream. Two overflows and a canal in concrete faced with brick were made at the same time.

For these overflows, and in other works, the author made his own bricks and used a mortar formed of clay and fat, quicklime, as suggested by Vicat. He described the resulting mortar as equal to that made with hydraulic lime.

CURRENT PRACTICE IN ENGINE PROPORTIONS.*

By John H. Barr,† M. Am. Soc. C. E.

In conjunction with Messrs. F. F. Gaines and H. E. Williams, the writer presented a paper at a former meeting of the Society (December, 1895), entitled the "Proportions of High-Speed Engines" (Engineering News, Dec. 19, 1895). The earlier paper explained our method of comparing practice and deriving general coefficients for use in formulas, but it gave only a few of these constants by way of illustration.

Since the presentation of the former paper, a similar investigation has been made upon "low-speed" engine proportions, mainly of the Corliss type; and the original data, with some additions, have recently been revised. The principal results are now presented.

The original computations on high-speed engines were made by Messrs. Gaines and Williams in the preparation of their graduating thesis in 1895. The work on low-speed engines was done by Messrs. L. J. Gray and W. S. Goll, and was presented by them as a thesis upon graduation from Sibley College, Cornell University, in 1896. Mr. T. A. Bennett of the present senior class, in the same institution, has assisted in putting the data into the shape which they now assume. The writer desires to acknowledge his obligations to these gentlemen for their painstaking efforts, and to especially express his great appreciation of the liberality with which many prominent engine-builders responded to the request for data.

Method of Procedure.

A printed form with spaces for insertion of over 50 items relating to the proportions of parts of engines was prepared and sent to various leading engine-builders, many of whom filled in the required data relating to from 3 to 16 different sizes of engines. The entire collection of material covers, more or less completely, nearly 200 engines, ranging from 20 to 725 HP. The information thus obtained was classified for comparison. Thus, for example, in dealing with crank-pin and main journal dimensions, the center-crank engines cannot be properly compared with side-crank engines, while the piston rods of such engines may be classed together, at least if the rotative speeds are not too widely divergent.

The following notation is used throughout this paper:

D = diameter of piston,
A = area of piston,
L = length of stroke,
S = steam pressure, taken at 100 lbs. per sq. in. above exhaust, as a standard pressure,
HP. = rated horse-power,
N = revolutions per minute,
C = a constant.

All dimensions in inches, unless stated to the contrary; other notation is explained as used.

The general method employed in deriving the various expressions may be illustrated by reference to that used for the diameter of the crank shaft at the main bearings:

Crank Shaft.—The formula for the diameter of a shaft which is subjected to torsion is: Diameter of shaft equals $C \sqrt[3]{HP. \div N}$, if the moment of torsion is constant.

Crank shafts are subject to variable combined bending and twisting moments; but these moments, when their magnitude and variation are known, can be reduced to an equivalent twisting moment; hence an expression of the above form applies to the case in hand, if the ratios between bending to twisting moments and between maximum and mean moments are constant. These ratios should not affect the form of the above expression, but only the value of the numerical coefficient. In the engines examined there is a general agreement as to the above ratios of moments among the engines of the same class. Of course this agreement is by no means mathematically exact; but the constants given in this paper are only intended to show the general trend of practice, and the diagrams exhibit the uniformity, or lack of uniformity, among the various builders as to certain proportions.

From the data at hand, points were plotted on cross-section paper with given values of d as ordinates, and the corresponding values of $\sqrt[3]{HP. \div N}$ as abscissas. All points obtained from the engines of one maker were connected by a conventional line. Some of the lines representing the dimensions of a single builder, presented a broken appearance which may be accounted for in part by the use of common fractions of an inch and by the frequent practice of using the same frame, crank shaft, etc., with different cylinders. A line is then drawn to represent the average of the observations, and lines are also drawn to embrace the extreme points. From the equations of these lines formulas are derived which represent the average and extremes of practice, as shown by the engines examined. The three formulas thus obtained differ only in the values of the constants.

The following results are derived from about 80 separate engines classed as high-speed engines, and about 85 engines classed as low-speed engines. Those in the former class range from 20 to 240 HP., and they represent the practice of 13 different builders. Those in the second class range from 45 to 740 HP., and they represent 12 different builders. Some of the data received could not, for various reasons, be used to advantage in our work. In some instances the number of engines considered was necessarily less than the above, but very few of the following coefficients are derived from less than 50 separate engines.

All of the engines from which these coefficients were derived are commercial forms which have been subjected to years of service; therefore, it is probable that dimensions somewhat smaller than those corresponding to the mean values of the various constants would secure reasonable safety under ordinary conditions. Commercial or engineering advantages may warrant the use of larger members in many cases.

The data used are all from simple engines, but it is believed that many of the results may be applied to compound engines by modifying them to comply with well-known relations.

The Cylinder.

Data on thickness of cylinder walls (shell), flanges, cylinder heads, and cylinder head bolts were obtained only for the engines classed as low-speed.

Thickness of Walls.—The shell of the cylinder must have sufficient thickness to resist the maximum bursting action and to avoid objectionable deformation, even after the cylinder has been rebored one or more times; and in small cylinders, for moderate pressures, the thickness necessary to insure good castings may be the prime requirement. Such considerations have led to the proposal of empirical formulas in which the steam pressure does not appear. While the use of this class of formulas is not in strict accord with a leading idea of the work here described, it has seemed well to adopt such an expression in this instance.

The general form of the expression that is very often employed:

$$t = C D + B,$$

in which t = the thickness of the shell in inches, D = the diameter of the piston in inches, and C and B are the constants. From the engines specified above it is found that C varies from .04 to .06, and that B = .3-in.

The general practice is expressed approximately by

$$t = .05 D + .3\text{-in.}$$

It seems not unreasonable to look upon the added constant of 0.3-in., found above, as an allowance for reboring, etc., and the coefficient C as one which should vary with the steam pressure. The engines considered in deriving the values given are all rated on from 80 to 100 lbs. pressure; hence, in using this formula for higher pressures, it would seem advisable to increase the value of C proportionately. Looked at from this standpoint, the above formula becomes a rational one.

Flange and Cylinder Heads.—The flanges and the cylinder heads usually have the same general thickness. This is found to vary from 1.0 to 1.5 times the thickness of the shell, the mean value being about 1.2 times the thickness of the cylinder wall.

Cylinder Head Studs.—There is no general agreement as to the number of studs nor their diameters. In the above-specified low-speed engines none have studs less than ¾-in. or more than 1⅛ ins. diameter. The least number of bolts is 8 for a cylinder 10 ins. diameter, and the greatest number is 32 for a cylinder 24 ins. diameter.

A large number of small bolts, as against a small number of large bolts, tends to secure tightness of the joint; but the smaller bolts are subjected to greater stress in screwing up. It may be mentioned in this connection that experiments made under the direction of the writer, show that the stress at the bottom of the thread, due to screwing up of a bolt, may equal or exceed $\frac{30{,}000}{d}$ lbs. per sq. in., in which d = the nominal diameter of the bolt.

The average number of bolts used in each head of the above engines is given approximately by

$$n = .7 D,$$

in which n = number of bolts, and D = diameter of piston in inches. Of course, the number given by this rule would usually be modified to secure an even number.

The general practice as to diameter of studs is represented nearly by

$$d = \frac{D}{40} + \tfrac{1}{2}\text{-in.}$$

d being the nominal diameter of the studs.

Ports and Pipes.

Areas of Ports and Pipes.—Area of port (or pipe) = a, in sq. ins; area of piston = A, in sq. ins.; mean piston speed = V, in ft. per minute. The relation of the port area (or pipe area) to area of piston and mean piston velocity is expressed by

$$a = \frac{A V}{C},$$

in which C is the mean velocity of steam through the port, or pipe, in ft. per minute.

Ports—High-Speed Engines.—(The same ports used for steam and exhaust.) For the general practice it is found that: Mean value of C = 5,500; maximum value, C = 6,500; minimum value, C = 4,500. As the piston speed is quite constant for a large number of these engines (about 600 ft. per minute), the area of port may be conveniently expressed by a = K A, in which K is as follows for the general practice: Mean value of K = 0.10; maximum value, K = 0.13; minimum value, K = 0.07.

Area of Steam Ports—Low-Speed Engines.—(Separate ports for exhaust.) For these engines it is found that the general practice is represented by: Mean value of C = 6,800; maximum value, C = 9,000; minimum value, C = 5,000.

In the relation a = K A, K varies for the general practice with these engines as follows: Mean value of K = 0.09; maximum value, K = 0.10; minimum value, K = 0.08.

Exhaust Ports—Low-Speed Engines.—With the same forms of expressions as above, designating area of the exhaust port by a, it is found that: Mean value of C = 5,500; maximum value, C = 7,000; minimum value, C = 4,000. Mean value of K = 0.11 = 1-9; maximum value, K = 0.125 = ⅛; minimum value, C = 0.10 = 1-10.

Steam Pipes—High-Speed Engines.—In the expression

$$a = \frac{A V}{C},$$

mean value of C = 6,500; maximum value, C = 7,000; minimum value, C = 5,800. As the piston speed is approximately the same in many of the cases, it is convenient to use the relation

$$d = K D.$$

It is found that mean value of K = 0.35; maximum value, K = 0.40; minimum value, K = 0.30.

Steam Pipes—Low-Speed Engines.—With these engines it is found that mean value of C = 6,000; maximum value, C = 8,000; minimum value, C = 5,000. Mean value of K = 0.32; maximum value, K = 0.38; minimum value, K = 0.26.

Exhaust Pipes—High-Speed Engines.—Mean value of C = 4,400; maximum value, C = 5,500; minimum value, C = 2,500. Mean value of K = 0.40; maximum value, K = 0.50; minimum value, K = 0.35.

Exhaust Pipes—Low-Speed Engines.—Mean value of C = 3,800; maximum value, C = 4,700; minimum value, C = 2,800. Mean value of K = 0.4; maximum value, K = 0.45; minimum value, K = 0.35.

Face of Pistons.

It is not to be expected that any very general agreement will be found in the practice of various builders as to the face, or width, of pistons.

*The following expression, in which F = face of piston, was employed to express the relation of face of piston to diameter of piston:

$$F = C D.$$

High-Speed Engines.—Mean value of C = 0.46; maximum value, C = 0.60; minimum value, C = 0.30.

Low-Speed Engines.—Mean value of C = 0.32; maximum value, C = 0.45; minimum value, C = 0.25. No data were obtained on the thickness of piston walls.

Piston Rods.

There are several methods of treating this member analytically, any of which might be taken as the basis of a formula in deriving constants by the general method used in this investigation.

It has seemed best to treat it as a long strut, to be designed for rigidity, inasmuch as any considerable buckling or flexure of the rod would induce objectionable friction and wear at the stuffing box, or possibly cramping of the piston. The Euler formula has been followed. It has the form

$$P = K' \frac{E I}{L_1^2}; \quad P = K \pi^2 \frac{E I}{L_1^2},$$

in which E = the modulus of elasticity; I = moment of inertia for the section; L_1 = the length of the strut; and

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* Abstract of a paper presented at the Hartford meeting of the American Society of Mining Engineers.

† Associate Professor of Machine Design, Sibley College, Cornell University, Ithaca, N. Y.

* Only horizontal engines are included in deriving the following coefficients.

P = the **greatest load consistent with stability. The value** of the constant K depends upon the end conditions; that is, upon whether the ends of the strut are "fixed" or pivoted, free or guided. The piston rod is considered as coming under the case in which the strut is fixed at one end and free at the other. It may be urged that the guides constrain the outer end; but many forms of guides are poorly adapted to exert constraint against lateral flexure, and it is better to provide the slight increase of diameter required to avoid such side pressure on the guides. In this case

$$K = \tfrac{1}{4}, \text{ or } P = \frac{\pi^2}{4}\,\frac{E\,I}{L_1^2}.$$

$$I = S\,\frac{\pi}{4}\,D^2\ ;\ I = \frac{1}{64}\,\pi\,d^4;$$

L_1 (in plotting) is taken equal to length of stroke L. Of course the free length of a piston rod is always somewhat greater than the length of stroke; but their ratio is not very different in most engines of a similar class; hence we may use L for L_1, with proper modification of the constant involved in the formula.

General practice will be assumed to show that the free length of piston rod $L_1 = 1.2L$ for high-speed engines, or that $L_1^2 = 1.4\ L^2$; and that $L_1 = 1.1\ L$ for low-speed engines, or $L_1^2 = 1.2\ L^2$.

Assuming S as a standard steam pressure of 100 pounds per square inch, and that E = 30,000,000, the Euler expression takes the form for high-speed engines (with $L_1^2 = 1.4\ L^2$):

$$100\,\frac{\pi\,D^2}{4} = \frac{\pi^2 \times 30{,}000{,}000\ \pi\,d^4}{4 \times 1.4\ L^2 \times 64},$$

or

$$d^4 = \frac{64 \times 100 \times 1.4}{30{,}000{,}000\,\pi^2}\ (D^2\ L^2);$$

therefore $d = 0.074\ \sqrt{D\ L}$.

In a similar way for the low-speed engines:

$$d = 0.07\ \sqrt{D\ L}\ \text{(taking } L_1^2 = 1.2\ L^2).$$

Both of these expressions are for a factor of safety unit. The general form for these expressions is

$$d = C\ \sqrt{D\ L}.$$

The actual data for the two classes of engines are treated as follows: The diameter of rod for a given engine is plotted as an ordinate, and the value of $\sqrt{D\ L}$, for the same engines, is plotted as an abscissa; and so on for each engine of which the data are available. A curve (straight line in this and many other cases) is drawn to represent the mean of all such points; also lines to include the extreme points, unless a few of these are found to be much out of the general range. The equations of these three lines give the mean, maximum, and minimum values of the coefficient C for the practice represented by the engines examined.

Piston Rods of High-Speed Engines.—Mean value of C = 0.145; maximum value of C = 0.175; minimum value of C = 0.12.

It will be seen that this mean value of C will give a diameter of rod greater than that required with a factor of safety of unity in the ratio of 0.145 to 0.074, or of 2 to 1 (nearly). As the strength of the long strut varies as the fourth power of the diameter, the factor of safety is

$$\left(\frac{0.145}{0.074}\right)^4 = 15.$$

Piston Rods of Low-Speed Engines.—Mean value of C = 0.11; maximum value, C = 0.13; minimum value, C = 0.10. The diameter given by this mean value of C is to the diameter with factor of safety of unity as 0.11 to 0.07, or as 1.57 to 1. This corresponds to a factor of safety of $\left(\frac{0.11}{0.07}\right)^4 = 6$.

While the conditions under which a high-speed engine operates may make a higher factor of safety proper with this type, it may be questioned whether so great a difference is really necessary. Two elements, not yet mentioned should be considered in this connection, however. The body of the rod should be not only stiff enough as a long strut, but the ends, where they are reduced by screw threads or key-ways, must have a section sufficient for the direct stress (tension and compression). The area of these reduced sections should be about the same, for engines of the same diameter (with similar materials and steam pressure), regardless of the length of stroke; hence the diameter of body of the rod which provides the required reduced area will give a greater margin with the shorter strokes. Furthermore: Since the strength of the long strut increases as the fourth power of the diameter, it requires an increase of diameter of less than 20% to double the factor of safety; therefore, the tendency to provide somewhat greater dimensions with high-speed engines than are common in low-speed engines of similar diameter of piston may easily lead to an excessive increase in the factory of safety in such a member as the piston rod.

Connecting Rods.

These are treated, like the piston rods, as long struts, except that the constants are different, owing to the end conditions. The connecting rod is "pin-ended," or round ended, as regards buckling in the plane of its motion, while it is to be treated as "square ended" against lateral deflection. Rods of circular cross-section need only be considered with reference to the plane in which they are most liable to buckle; viz., in the plane of their motion. Rods of rectangular section (or of approximately rectangular section) are liable to buckle in either plane, depending upon the relation of the height, h, to the breadth (thickness), b, of the section.

The Euler formula for a pin-ended strut is

$$P = \pi^2\,\frac{E\,I}{L_1^2},$$

and for a square-ended strut it is

$$P = 4\,\pi^2\,\frac{E\,I}{L_1^2},$$

in which P is the greatest load consistent with stability; E is the modulus of elasticity; I is the moment of inertia of the mid-section; and L_1 is the length of the struts.

Connecting Rods of High-Speed Engines.—(Rectangular sections only.) Connecting rods, generally six cranks long. It can be shown from the above expressions that a rectangular strut with end conditions as in connecting rods, under static load, should have a cross-section such that the dimensions in the plane of the pin axes is one-half of the dimensions perpendicular to this plane, or h = 2b. In engine connecting rods, the value of h is considerably greater than 2b. This excess of h over 2b may be considered as an allowance for the inertia action (centrifugal throw) on the rod; that is, we may consider the strength of the rod against the thrust as determined by the breadth b and a height 2b. Then, for lateral flexure,

$$I = 1\text{-}12\ b^3\ h = 1\text{-}12\ b^3 \times 2b = 1\text{-}6\ b^4.$$

with a load $P = \tfrac{1}{4}\,\pi\,D^2\,S$ (in which S is taken at 100 lbs. per sq. in.), a factor of safety of unity, and E = 30,000,000:

$$\tfrac{1}{4}\,\pi\,D^2 \times 100 = 4\,\pi^2 \times 30{,}000{,}000 \times \frac{b^4}{6\ L_1^2},$$

Therefore $b = 0.025\ \sqrt{D\ L_1}$.

Adopting the expression

$$b = C\ \sqrt{D\ L_1}$$

for the connecting rods, plotting b and $\sqrt{D\ L_1}$ of each engine as co-ordinates, and drawing lines to represent the mean, maximum and minimum of the general practice, the following values of C are obtained: Mean value of C = 0.057; maximum value, C = 0.07; minimum value, C = 0.045.

This mean value of C indicates a factor of safety of $\left(\frac{0.057}{0.025}\right)^4 = 25$.

A comparison of the heights, h, and breadth, b, at mid-section of the above rods shows that in the relation h = K b. Mean value of K = 2.7; maximum value, K = 4.0; minimum value, K = 2.2.

Connecting Rods of Low-Speed Engines.—(Circular sections only.) Connecting rods generally five and a half cranks long. For flexure in the plane of motion

$$\tfrac{1}{4}\,\pi\,D^2\,S = \tfrac{1}{4}\,\pi\,D^2 \times 100 = \pi^2 \times 30{,}000{,}000 \times \frac{\pi\,d^4}{64\ L_1^2}.$$

Therefore $d = 0.048\ \sqrt{D\ L_1}$ (for factor of safety or unity). Using the general expression

$$d = C\ \sqrt{D\ L_1},$$

plotting d and $\sqrt{D\ L_1}$ as the co-ordinates, and drawing mean and extreme lines as before: Mean value of C = 0.092; maximum value, C = 0.105; minimum value, C = 0.082.

This means value of C indicates a factor of safety (neglecting the whipping of the rod) of

$$\left(\frac{0.092}{0.048}\right)^4 = 13.$$

Crosshead Shoes.

The area of the crosshead shoes which sustain the vertical component of the force of the connecting rod is expressed in relation to the area of the piston by

$$a = C\ A.$$

The maximum pressure per sq. in. of shoe, p (if the steam follows up for half stroke), is nearly equal to S A ÷ n a, in which n is the ratio of connecting rod length to the crank. Hence, with S = 100 lbs. per sq. in.:

$$p = \frac{100\ A}{n\ a} = \frac{100\ A}{n\ C\ A} = \frac{100}{n\ C}\ \text{(nearly)}.$$

Crosshead Shoes of High-Speed Engines.—

$$p = \frac{100}{6\ C} = \frac{17}{C}$$

Mean value of C = 0.63; maximum value, C = 1.60; minimum value, C = 0.45. Mean value of p = 27; maximum value, p = 38; minimum value, p = 10.5.

Crosshead Shoes of Low-Speed Engines.—

$$p = \frac{100}{5.5\ C} = \frac{18.5}{C}$$

Mean value of C = 0.46; maximum value, C = 0.64; minimum value, C = 0.32. Mean value of p = 40; maximum value, p = 58; minimum value, p = 29.

Crosshead Pins.

The relation of the projected area of crosshead pin to area of piston is

$$a = (d\ l) = C\ A.$$

The ratio of diameter to length of crosshead pin is expressed by l = Kd.

Crosshead Pins of High-Speed Engines.—Mean value of C = 0.08; maximum value, C = 0.11; minimum value, C = 0.06. Mean value of K = 1.25; maximum value, K = 2.0; minimum value, K = 1.0.

Crosshead Pins of Low-Speed Engines.—Mean value of C = 0.07; maximum value, C = 0.10; minimum value, C = 0.054. Mean value of K = 1.3; maximum value, K = 1.5; minimum value, K 1.0.

Crank Pin.

The lost work per minute due to friction of a journal may be expressed by $P\ \mu\pi d\ N$, in which P = mean pressure on the journal; d = diameter of the journal; N = revolutions per minute; and μ = the coefficient of friction.

The heat resulting from this frictional work is dissipated through a surface which is proportional to the projected area of the journal (d l), and reason and experience indicate that this projected area should be about proportional to the heat so dissipated.

Therefore

$$\frac{P\ \mu\pi d\ N}{d\ l} = \frac{P\ \mu\pi\ N}{l} = K.$$

Therefore

$$l = \frac{P\ \mu\pi\ N}{K}.$$

In an engine, if P = the mean total pressure on piston,

$$P = \frac{12 \times 33{,}000\ HP.}{2\ L\ N}.$$

Therefore

$$l = \frac{12 \times 33{,}000 \times \mu\pi\ HP.}{2\ K\ L} = C\,\frac{HP.}{L}.$$

Upon plotting the data, it was found that the length is expressed better by the form

$$l = C\,\frac{HP.}{L} + B$$

(in which B is an added constant) than by the above rational form.

Projected area of crank pin: (d l) = K A.

Crank Pins of High-Speed Engines.—Mean value of C = 0.30, of B = 2.5 ins.; maximum value of C = 0.46, of B = 2.5 ins.; minimum value of C = 0.13, of B = 2.5 ins. Mean value of K = 0.22; maximum value, K = 0.40; minimum value, K = 0.10.

Crank Pins of Low-Speed Engines.—Mean value of C = 0.6, of B = 2 ins.; maximum value of C = 0.8, of B = 2 ins.; minimum value of C = 0.4, of B = 2 ins. Mean value of K = 0.09; maximum value, K = 0.115; minimum value, K = 0.065.

Crank Shafts Main Journals.

The method of treating the diameter of the crank shaft at main journal was referred to in the introductory portion of this paper. The expression used is

$$d = C\ \sqrt[3]{\frac{HP.}{N}}$$

The ratio of length to diameter of main journal is expressed by l = Kd.

The projected area of the main journal is given in terms of the piston area by d l = M A.

Main Journals of High-Speed Engines.*—Mean value of C = 7.3; maximum value, C = 8.5; minimum value, C = 6.5. Mean value of K = 2.2; maximum value, K = 3.0; minimum value, K = 2.0. Mean value of M = 0.46; maximum value, M = 0.70; minimum value, M = 0.37.

Main Journals of Low-Speed Engines.†—Mean value of C = 6.8; maximum value, C = 8.0; minimum value, C = 6.0. Mean value of K = 1.9; maximum value, K = 2.1; minimum value, K = 1.7. Mean value of M = 0.56; maximum value, M = 0.64; minimum value, M = 0.46.

Piston Speed.

The mean piston speed, or the piston travel in ft. per minute, is

$$V = \frac{2\ L\ N}{12} = \frac{L\ N}{6}.$$

High-Speed Engines.—Mean value of V = 600; maximum value, V = 660; minimum value, V = 530.

Low-Speed Engines.—Mean value of V = 600; maximum value, V = 850; minimum value, V =500.

Weight of Reciprocating Parts.

The weight of piston, piston rod, crosshead, and connecting rod was obtained. These weights are plotted only for the high-speed engines.

For engines having similar compression, smoothness of running (in passing the dead-points) indicates that the weight of reciprocating parts, W, should be proportional to $\frac{D^2}{L\ N^2}$. Taking the reciprocating parts as made up of the piston, piston rod, crosshead and one-half the connecting rod, the diagram was obtained by plotting the weight of these parts as abscissas, and the corresponding

* These values are for each of the two journals of center-crank engines.

† One journal only; side-crank engines.

values of $\frac{D^3}{L\ N^3}$ as ordinates.

$$W = C\ \frac{D^3}{L\ N^3}.$$

Mean value of C = 1,860,000; maximum value, C = 2,300,000; minimum value, C = 1,200,000.

Belt Surface Per I. HP.

The relation of belt width and velocity to the indicated horse-power is expressed by S = C (HP.), in which S is the product of the width of belt in feet multiplied by the velocity of the belt in feet per minute.

*High-Speed Engines.—Mean value of C = 55; maximum value, C = 70; minimum value, C = 40.

Low-Speed Engines.—Mean value of C = 35; maximum value, C = 42; minimum value, C = 30.

Flywheel.

Data as to flywheels were obtained for the high-speed engines only.

The weight of rim is expressed by

$$W = \frac{C\ HP.}{D_1^2\ N^3},$$

in which W = weight of the rim in pounds, and D_1 = diameter of the wheel in inches.

Mean value of C = 1,200,000,000,000; maximum value, C = 2,000,000,000,000; minimum value, C = 650,000,000,000.

The velocity of rim in these engines has a general value of about 4,200 ft. per minute, or 70 ft. per second.

Weight of Engine Per I. HP.

The weight of engine (including flywheel) per I. HP. is W = C HP.

High-Speed Engines.—Mean value of C = 115; maximum value, C = 135; minimum value, C = 100.

Low-Speed Engines.—Mean value of C = 175; maximum value, C = 240; minimum value, C = 135.

BOOK REVIEWS.

AMERICAN STREET RAILWAY INVESTMENTS.—A supplement to the "Street Railway Journal." Published for the use of builders, brokers, capitalists, investors and street railway companies. 1897. Street Railway Publishing Co., New York. 10 × 12¾ ins.; 290 pp.; maps. $3.

This annual publication takes up in detail the street railways of the United States, gives the population in 1880 and 1890 and the capital stock and funded debt of the street railway companies, together with a description of their plant and equipment. A valuable departure from similar publications is the date of information attached to each report. Of the 1,262 companies reporting 930 are operating, 206 are leased companies, and 117 are under construction but not in operation. Of these companies 27 earned, in gross receipts, in 1896, over $1,000,000 each; 22 companies earned from $500,000 to $1,000,000; 52 earned from $100,000 to $500,000; 56 from $50,000 to $100,000, and 38 properties earned from $25,000 to $50,000. In the first group the average rate of increase over the gross earnings of 1895 was 6.67%; in the second group, 6.47%; in the third group, 12.14%; in the fourth group, 9.18%, and in the fifth group, 15.94%. Of the total 195 properties 72.09% of the total receipts for 1896 are credited to the 27 companies in the first group; the aggregate gross receipts for these companies being $83,920,417 for 1896, as compared with $78,672,268 in 1895. All of these 27 companies show increased earnings in 1896, except the Manhattan Elevated, the Brooklyn Elevated, the Louisville Ry. Company, the Detroit Citizens Street Ry. Company and the Capital Tracking Company. These named show decreased earnings for the year of 4.34, 17.45, 4.16, 1.41, and 2.75% respectively. The gross receipts of the second class of companies, for 1896, aggregate $14,765,754; for the third class, $12,727,393; for the fourth class, $3,650,297, and for the fifth class, $1,325,459. The detailed information of these companies is arranged alphabetically under the names of the towns and cities; but no general summary is included other than that of gross earnings noted above.

MANUAL OF IRRIGATION ENGINEERING.—By Herbert M. Wilson, C. E. Second edition, revised and enlarged. New York: John Wiley & Sons. London: Chapman & Hall. Cloth; 6 × 8½ ins.; pp. 538; 163 illustrations. Price, $4.

This edition contains about 50% more matter than the first one, which was reviewed in our issue of March 30, 1893. In the present edition the sections on hydraulics have been extended and some tables and formulas added. The chapter on subsurface water sources has been almost wholly rewritten and matter added relating to artesian wells and the use of sewage for irrigation. Descriptions, with illustrations of additional irrigation works, have been included in this volume.

In commenting on the control of irrigation works the author refers to government ownership of such undertakings abroad and then states that in the United States "all irrigation works are the property of individuals." From this statement no one would ever suspect the existence of irrigation districts in California and laws permitting the formation of such districts in several other states.

The works supplying these districts are built by the districts as a whole and maintained from the proceeds of the general tax levy, in practically the same way as a city builds and maintains a water-works system.

Bibliographies are presented at the end of each chapter, which add to the value of the book. No reference is made, however, in the proper place, to the report of Mr. C. C. Vermeule on "Water Supply," forming Vol. III. of the "Final Report of the Geologist of New Jersey." This volume contains a large amount of information on rainfall, run-off and allied subjects.

The omissions named are not matters of great importance. The book is a good one, and now that Flynn's "Irrigation Canals and Other Irrigation Works" is out of print Mr. Wilson's work is the only American treatise on the subject.

IRRIGATION IN THE MADRAS PRESIDENCY.—Report of the Public Works Department, Irrigation Branch, for the Year 1895-6. Col. R. R. E. Drake-Brockman, R. E., Chief Engineer for Irrigation. Boards; 8 × 13 ins.; pp. 113; illustrated. Madras: Printed by the Superintendent, Government Press. Price, 5 rupees 8 annas (nominally $2.64; $1.27 according to "World Almanac" of recent actual value).

This volume gives an account of the irrigation operations of the Madras Presidency of India during the year named. The vast extent of the work reported on may in part be appreciated by knowing that there are 36 canal systems in charge of the department under which there are over 2,500,000 acres of irrigable land at present. The mileage of main, branch and distributing canals included in these systems is over 7,500, of which about 1,252 miles are open for navigation and showed a ton mileage for the year of over 50,000,000, carrying 465,624 passengers.

An appendix, illustrated by six photographs made by the Photo-Print Survey Office, Madras, describes briefly the Sangam anicut system. This system is designed to irrigate 94,000 acres, of which 77,347 were irrigated in 1895-6. The project was sanctioned in 1881 and the works came into operation in 1886-7. The project included the building of a masonry weir, or low dam, 4,290 ft. long; headgates with 40 outlets each 4½ ft. wide; a canal 6 miles long with a bottom width of 157 ft.; distributing canals; and improvements to works previously built.

The report contains a number of maps of different irrigation systems and diagrams of gagings of the flow of a number of rivers.

CORPORATION FINANCE.—A Study of the Principles and Methods of the Management of the Finances of Corporations in the United States, with Special Reference to the Valuation of Corporation Securities. By Thomas L. Greene, Auditor Manhattan Trust Co. New York and London: G. P. Putnam's Sons. Cloth; 5½ × 8 ins.; pp. 181. Price, $1.25.

This is a most admirable little book for all interested in private corporations, whether through actual connection as officers, attorneys or shareholders, or through public positions as legislators or judges, or simply as students of economics and public affairs. In one way or another corporations affect us all mightily at every turn. We are now almost absolutely dependent upon them for transportation and largely so for many of the most common necessities of life. Low prices for most services and commodities are directly influenced by the financial management of corporations, while indirectly the effect of such management reaches everywhere. The officers of corporations need a more thorough understanding of corporation finance; and the same is true of the general public, for its opinions and prejudices are largely responsible for many corporation methods and for much of the legislation on the subject.

The volume under consideration lays down some of the sound business principles which should guide in the management of corporations and in making investments in such securities. First of all, there is a general explanation and discussion of bonds and stocks and of the different forms of corporate enterprise. Next railway bonds and subsidiary companies (mostly railways) are considered. Then corporation accounting and the examination of railway reports is taken up. There is an interesting chapter entitled "Public Policy Towards Corporation Profits." The closing chapter discusses reorganizations and receiverships.

It would be well for many corporations to take to heart these words of the author:

> The best defence of corporations against unduly severe laws is full publicity. The history of a company, its early losses and struggles, the prices of the commodity when the business was begun compared with the prices now, the cost of production per pound or gallon or barrel, showing the reduction, and in view of such facts the moderate profits of to-day—statements such as these will prove to be the best defence against drastic legislation before the bar of public opinion. But a company relying upon such a defence must be sure that its course as regards prices and policy is one which cannot be fairly attacked.

The following suggestion relating to railway equipment and terminals may be quoted as showing how the author takes into consideration the many phases of his subject:

> In the approaching days when the use of air-brakes for freight trains and of one pattern of freight-car coupler will increase the number of trains which may be moved rapidly and safely over any particular piece of road, the capacity of the terminals rather than that of the track will even more than at present prove the standard by which the limit to the volume of traffic will be measured.

Stock-watering, the author thinks, is largely due to the very public that protests against it. Of his remarks on this subject the following may be quoted:

> The remedy for stock-watering, therefore, even in its innocent form, is not additional law, but a change in public opinion which shall allow the payment of 10, 12, or 15%, if legitimately earned, to the shareholders of corporations organized for business purposes. It would certainly be a gain in honesty if the capital of a company could openly be stated at a sum no larger than the amount actually invested. This would be the result much oftener than now if such returns as are above suggested could, without protest—because of that fact—be paid if earned. But this is not all. The community by its feeling against high corporation dividends deprives itself of a certain natural protection against unfair earnings; because if such were openly paid competition would be oftener attracted. The tendency of an open return would be toward a lower return. In the case of the Chicago, Rock Island & Pacific Co., just mentioned, the extreme profitableness of traffic-carrying in the years following 1880 was found not to be lasting. After paying 7% in dividends upon the doubled stock yearly, from 1882 to 1887, the company distributed but 4% in the years from 1889 to 1893, thus bringing the real returns to about the same rate as ruled before the watering. Had the original capital not been doubled this latter return would not seem so small. What the community has lost in freights and facilities, through the efforts of the managers to pay dividends on doubled capital at a rate which should nominally be as high as the usual interest on borrowed money, can only be a matter of conjecture.

What rate of dividend the public should be expected to tolerate without protest we shall not discuss, but with the idea that it would be better to make capital stock correspond with capital actually invested we agree.

THE IMPROVEMENT OF DELAWARE HARBOR, at Philadelphia, is reported upon by Major C. W. Raymond, Engineer Corps, U. S. A., in charge. The report gives in detail the work for the fiscal year ending June 30, 1897. In the year 3,956,027 cu. yds. of material were taken from the channel between Philadelphia and Camden, and 594,766 cu. yds. of this was used in filling at League Island Navy Yard. Since the commencement of work a total of 18,626,766 cu. yds. has been excavated from this harbor. As a general result the channel is 26 ft. deep for a length of 6.2 miles, and it has a maximum width of 1,000 ft. and a mean width of 978 ft. Over what was once Smith and Windmill Islands there are now 25 ft. of water at low tide.

THE IMPROVEMENT OF THE CHICAGO RIVER by widening and deepening its channels is one of the important projects now under consideration, and Gen. John M. Wilson, Chief of Engineers, U. S. A., has recently made a visit of inspection along the river in company with Major W. L. Marshall, U. S. Engineer Corps, who is in charge of the work of the Chicago district. The following is a statement prepared by Major Marshall in regard to the present capacity of the river:

> Boats 325 ft. long and 42 ft. beam can navigate the Chicago River to the elevators, drawing, after the dredging is completed, barely 16 ft. at the present stage of water (5 ft. above Chicago city datum). The crown of Washington St. tunnel now limits the draft as stated. Over La Salle St. tunnel a draft of 17 ft. is now barely possible over the central part. Over Van Buren St., 18 ft. is practical at the present stage.
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> Each foot additional draft in vessels of the dimensions named (allowing 20 ft. off for the run or mold at bow or stern, or of rectangular horizontal dimensions, 305 × 42 ft.) corresponds in round numbers to 400 tons cargo, or about 13,300 bushels of wheat.
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> If the available draft were 20 ft. the cargoes carried by the same vessels could be increased 1,600 tons, or about 53,000 bushels of wheat. This would result simply by the removal of tunnels and deepening of the river channel and minor changes in docks now contemplated, so that the capacity of boats of the same beam and length could be increased from 33 to 50%.

THE U. S. BATTLE SHIP "INDIANA" may have to be sent to Halifax for docking and the placing of bilge-keels upon her hull, owing to the fact that the new Brooklyn dock is out of service, owing to faulty construction, and the Port Royal yard is without the facilities for placing the keels. These are the only two United States docks on the Atlantic coast large enough to take this ship. The "Indiana" has not been docked since May, 1896, when she was in the Port Royal dock. But this latter dock is difficult of access, owing to a tortuous and too shallow channel, and there is no anchorage outside. An appropriation of $200,000 has been made for improving the approach, but the work is not completed. It will be necessary to obtain the permission of the British government before using the Halifax dock, and the Secretary of the Navy is said to be now attending to this preliminary. The present want of facilities for docking our large war ships, with two docks on hand built for this purpose, but out of service for structural and other reasons, is a severe comment upon the methods of our Bureau of Yards and Docks.

*It is observed from the diagram plotted for belt surface per I. HP., with the high-speed engines, that the smaller engines have the greater surface per HP. This is perhaps owing to the thinner belts used with small engines. As a result the mean line on this diagram does not pass through the origin, and the relation of S to HP. is expressed more accurately by S = C HP. + B, in which B = 1,800; and C varies from 21 to 40, the mean value of C being about 28.